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SELECTIONS
FROM
THE RECORDS
OF THE
GOVERNMENT OF BENGAL.

No. XXXV.

PAPERS
RELATIVE TO THE
CUTTACK RIVERS.
PART II.

Published under the orders of the Government of India,
P. W. D. No. 365, dated 17th January, 1860.

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SELECTIONS

FROM

THE RECORDS

OF THE

GOVERNMENT OF BENGAL,

BEING

PAPERS

ON THE

SUBJECT OF THE

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PART II.

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PAPERS

CONNECTED WITH THE

BRUSHWOOD OPERATIONS

IN THE BED

OF THE

KATJOOREE RIVER.

PAPERS

RELATING TO

THE CUTTACK RIVERS.

From the Officiating Chief Engineer, Lower Provinces, to the Secretary to the Government of Bengal, Fort William.—(No. 2967, dated 17th August, 1858.)

SIR,

I HAVE the honor to submit for the information of His Honor the Lieutenant-Governor of Bengal, the accompanying copy of a letter from Captain Beadle, the Superintendent of Embankments, and an original report by Mr. Civil Engineer, T. W. Armstrong. Executive Engineer, Central Cuttack Division of Embankments, with a set of illustrative plans and sections of the improvements which have been effected in the bed and channels of the Katjooree river near the Cuttack Revetment, by the brushwood operations which have been carried on since the year 1855.

2. This Report has been very clearly and carefully drawn up, and fully illustrates the important works which have been carried on in the bed of the Katjooree. It clearly shows the manner in which the money sanctioned by Government for the brushwood operations has been expended, and the results which have attended these experiments.

3. Mr. Armstrong had displayed much skill and care in his work and in the preparation of this report, and deserves credit for it.

4. The return of the original report and drawings is requested when no longer required.

From the Superintendent of Embankments, to the Officiating Chief Engineer, Lower Provinces, Midnapore.—(No. 907, dated 17th July, 1858.)

SIR,

I HAVE the honor to submit a very clearly and completely described set of plans, shewing the effect of the brushwood operations in the bed of the Katjooree, upon the Cuttack Revetment, which had been constantly breached by the deep side channel that had formed along it.

2. After the rains of 1854, Captain Short, then Officiating Executive Engineer of the Cuttack District, cut a mid channel in the sand and forced a portion of the cold weather volume down it, but the state of the river bed in June 1855, shews that this diversion did but little permanent good. Mr. Armstrong's letter describes fully the subsequent proceedings of Captain Harris and himself in forming the brushwood spurs.

3. I have commented on the necessity of carefully adhering to the cautious procedure stated in the 18th paragraph as necessary on account of the danger of diminishing the sands at the head of the Khokhai outlet, and I have expressed to Mr. Armstrong my satisfaction at the way in which he has taken up this work.

4. I hope the plans, which are fully explanatory, may be placed before His Honor the Lieutenant-Governor, as shewing that the small sums entered annually in the budget for brushwood operations have produced most useful results, and I consider that Mr. Armstrong deserves to be complimented on the care and ability he has shewn in drawing up this excellently well illustrated report, and that he deserves great credit for his management in reducing the rates and expense of the work. The former spur I thought cheap at eight annas the running foot, and the Civil Engineer has now done the same work for 5 annas, however, at a more favorable season.

5. I do not consider the gap made in the brushwood spur recently completed of any consequence, and such accidents must be looked for in temporary work fixed into sand.

6. Precaution is certainly better than patch-work, and it is much less expensive; each breach in the Revetment cost a large sum of money in the reconstruction of the wall, and these temporary operations must be continued from time to time at the judgment of the Officer in charge.

From the Executive Engineer, Central Cuttack Embankments Division, to the Superintendent of Embankments, L. P.—(No. 97, A. dated Cuttack, 3rd July, 1858, Despatched 9th July, 1858.)

SIR,

IN continuation of my No. 82 of the 28th ultimo forwarding a set of Plans and Sections, illustrative of the improvements which have been effected in the bed and channels of the Katjooree River near the Lall Bagh Revetment by the brushwood operations which have been carried on here since 1855, I beg to offer the following remarks by way of explanation of my plans and the brushwood works under notice.

2. Captain Harris of the Bengal Engineers shortly after his arrival here as Executive Engineer of the Embankments of the Cuttack division had his attention directed to the very unsafe state, the principal protective work of this station lay in, from the great depth of the pool of water that was situated at the toe of this work, and which is so well known by the name of the Lall Bagh Revetment.

3. The foundations of the Revetment may, on the average, be taken at 94 over datum. The height of the low water in the Katjooree is about 95.50. Its depth in 1855 in the deep pool shewn in Plate I. varied from 4 to 36 feet, the water being at 95.50, consequently the bottom of this reservoir, which at the time of low water it truly is, was from 2½ to 34½ feet under the foundations of the Revetment.

4. I shall best describe that work by quoting Captain Harris' description of it in his report, Part 1, on the control of the Mahanuddy's floods.

"The Revetment may be described as an irregular line of masonry "partaking of the character of a wall; in some portions, of a simple "casing; in others, constructed of large blocks of laterite and sandstone, "set in mud cement and painted with lime plaster exteriorly. The height "of its crest varying from 17 to 36 feet above the low water line, and "width at top and bottom respectively from 3 to 4 and 5 to 8 feet."

5. I am of opinion that the Revetment wall, including its many bastions and projecting buttresses, has been entirely built upon the natural or maiden earth along its site.

I do not consider any artificial foundation was attempted when the work was built, nor has any been more recently tried for the founding of the many new portions erected where breaches occurred. This season

I under-pinned a small portion of the Salt Golah Bastion.* The foundations of that under-setting are laid from 3 to 4 feet under the foundations of the old wall, these I dried and laid bare, to enable me to execute the repairs, and I could trace nothing artificial about the foundations of the bastion, the first course being laid on the natural clay, set with mud cement like the rest of the work over head, and painted with lime plaster. In another place near a bastion, where I carried out a second piece of under-pinning, the old wall was exactly similar to that of the Salt Golah Bastion.

* At X. vide plate I. fig. I.

6. With reference to the latter part of para. 3, it may well be asked, how could the Revetment stand and bear up against back pressure with its foundation from 2½ to 34½ feet above the bed of the river immediately under its foot? For many years previous to 1855, breaches have frequently occurred, and in fact they have been so numerous that near the Lall Bagh scarcely a moiety of the original wall exists at the present time. I saw one breach occur in 1855, just after the great flood of that year. Most probably, like its predecessors at other places, it moved bodily outwards from its site. After a short time the mass commenced to sink and break up into large fragments, finally disappearing gradually into the eroded reservoir, the existence of which caused it to subside, and whose creation by the violent and direct impinging action of the Katjooree's flood ensured the breach taking place, sooner or later.

The debris of this breach was the foundation of the new work, and upon it was erected the masonry needful to repair the accident and protect the city of Cuttack from the great damage an irruption of the Katjooree's water through the gap left by the fallen wall would certainly inflict.

7. This has been, previous to 1855, the universal practice, as any observer can perceive by walking along the Revetment and looking at the herm that the wall is built upon. Masses of masonry and blocks of laterite and sandstone lie in one amalgamated heap. These formed the materials and substance the former Revetment was composed of, and now act as the foundation and herm of the present work.

8. The practice of rebuilding the Revetment where a breach occurred on the ruins of the fallen wall was easy enough to carry out, these ruins forming, at the time, a firm strata upon which to erect the new masonry.

9. Permanent, however, it was not, for in time even this debris and artificial foundation would be undermined, and the channel at its side which was partially filled up at the time the accident occurred by the fragments and materials of the tumbled revetment, would be widened and deepened by the same action that created the original deep pool, thereby enticing this created herm to subside or slip outwards weighted as it was with the new masonry erected upon it.

10. No work, at any rate no successful one, was, prior to 1855, attempted, so as to prevent the continued breaching of the revetment, modify the impinging action of the flood upon it, or decrease the great depth of the pool lying along its base. Captain Harris instead of following the course of his predecessors, struck out a new and correct path for himself, and wisely determined not to wait till the revetment was breached to repair it, but to try and prevent such breaching from taking place: he then instituted, I may say, designed, the brushwood works that have, simple as they are, been attended with, I am safe in saying, such immense beneficial results at a very small outlay, in the whole, amounting to about Co.'s Rs. 1662-3-0.

11. I think any person looking at the plans and sections I have drawn and knowing that they are correct delineations of the river Katjooree, its bed and sand banks, at the Lall Bagh in 1855, and as it was on the 9th of last month will arise from their examination satisfied that great good has been done; that the Lall Bagh revetment is now in a safe state and the likelihood of another breach (the repair of which would be an expensive proceeding*) is not at all probable.

* The repair of the breach of 1855 cost Rs. 2,350.

12. This state of things must be deemed satisfactory, when it is known that the revetment is the chief protective work of the city and station of Cuttack, also that the high flood level in the Katjooree is 6 feet higher than that of the Mahanuddy, taking a line across through the city from the Lall Bagh to the Cantonments on the banks of the Mahanuddy, and that if an irruption of the Katjooree's flood occurred by a breach in the revetment, portions of the town would be inundated to a depth of from 5 to 8 feet; as the ground parts of the city and the gaol are built upon is that number of feet under the high flood level of the Katjooree.

13. The brushwood operations instituted by Captain Harris have removed the likelihood of such a catastrophe as the flooding of Cuttack

would be by the revetment giving way and he has every reason to be satisfied at the results of his labours. His designs and example I have, in the brushwood works of this year, strictly followed, as I am convinced that none more suitable for the locality could be proposed and that I should be doing wrong, and risking the means placed by the Government at my command, did I otherwise than continue in the same manner in 1858 the "spur building" and "brushwood sinking" of 1855 and 1856, which are so simple in execution, attended with small outlay and very satisfactory results.

14. To explain my plans and sections, I would state that plate 1, is a plan of the revetment from the old Salt Golah bastion at X. to G. a point about 1800 feet up stream of the Hurreeree Ghat at Bellvue. Within the points named, is the portion of the revetment which has suffered so much from the attacks of the Katjooree flood.

The survey of 1855 shows the extent of the pool of deep water lying in the month of June of that year at the toe of the wall, while that of 1858 shows the size of the reservoir (as I have called it) in June of this year. The difference is very striking. Along the dotted line the water is 4 feet deep, when it stands at 95, 50; on the guage inside is the deeper water, as shewn by the darker blue tint.

The dotted lines lettered from G. to X. inclusive, point out the positions that cross sections of this deep reservoir were taken at identical points in June 1855, 1856, 1857 and 1858, and the mouth of the stream flowing into this basin in 1855 and in 1858 is also drawn. It is remarkable how much larger that of this year is than the one that existed in June 1855. At that period nearly all the dry weather stream discharged in May and June, flowed down the Mahanuddy, but latterly the sands at Narage, have so silted up along the river's left bank near Kucker, as to cause nearly all the present summer water (as I may call it) to flow down the Katjooree.

15. Plates 2 and 3 are cross sections taken at the points indicated on plate 1. and referred to these points by letters similar to those on the plan.

These sections are principally drawn to shew decrease in depths, so that they are drawn and were taken merely across the permanent deep water, as the width of the channel when not deep is immaterial as regards the safety of the revetment.

I beg especial attention to these cross sections. I consider that com-

paring the cross sections of the years 1855 and 1858 on the lines H. H., J. J., L. L., F. F. and M. M., the depth silted up has been really surprising, considering the simple means used to effect it.

On H. H. the bottom of the deep channel running under the revetment wall in 1855 was 80 feet over datum.

On ditto in 1858 ditto is 101 ditto.

The silting has been 21 feet.

On J. J. in 1855 ditto ditto was 66 over datum.

On ditto in 1858 ditto ditto is 91 ditto.

The silting up has been 25 feet.

On L. L. in 1855 ditto ditto was 59½ feet over datum.

On 1858 ditto ditto is 95½ ditto ditto.

The silting up has been 36 feet.

On F. F. in 1855 ditto ditto was 66½ over datum.

On ditto ditto in 1858 ditto ditto is 96½ ditto.

The silting up has been 30 feet.

On M. M. in 1855 ditto ditto was 66½ feet over datum.

On ditto in 1858 ditto ditto is 93 ditto ditto.

The silting up has been 26½ feet.

These are the most favorable, but there is no reason to doubt but that if greater depths existed on the cross sections taken at the other points in 1855, similar favorable results would have followed. Wherever silting up was really required, there it has taken place. Some persons may cavil at or doubt that our brushwood works caused this great improvement and satisfactory state of things, but it cannot be denied that, before the brushwood operations were commenced by Captain Harris, a deep and dangerous pool lay at the toe of the revetment wall, into which portions of that work were so frequently falling, that not a moiety in many places remains of the original work; and that now comparatively speaking no such basin exists. Lately when walking under the bastion at the Lall Bagh, I could not but remember that where I then stood dry, there existed at the time I first saw this work a pool* of water from 28 to 36 feet deep, and whose bottom was from 25½ to 33½ feet below the foundation of the high wall above me.

* In June 1855.

16. Plate 4 is a longitudinal section of the revetment showing the bed of the deep channel lying under the work in 1855, 1856, 1857 and 1858.

The silting up is shewn by a brown tint, darker than that of the body of the section.

The bottom of the channel in the different years is plotted from the cross sections. Upon the section is also shewn the raising work that I executed this year. The parapet walls which have been strengthened by earth at the same time. The flood lines of 1855 and 1857. The water line of June 9, 1858, 95.50 over datum. The Bellvue guage, to which all our levels are referred, and other explanatory details.

17. Plate 5 consists of plans of the sands, bed and channel of the Katjooree after the floods have subsided. They are for 3 seasons, viz.:

Fig. No. 1 is plan before floods of 1856.
" No. 2 ditto ditto of 1857.
No. 3 ditto ditto of 1858.

No. 1 shews the sands and bed &c. of the river when the spur of 1856 was built. Upon No. 2 is depicted the same, one year later, though more in detail, still the great changes that were taking place in the sands consequent on the erection of the spur of 1856 can be readily observed.

Plan No. 3 surveyed in June last, shows the sands as they settled down during the floods of 1857, and though like the survey of 1856 it is not so detailed as that of 1857, yet such want of detail is of no consequence. The sandbanks are shewn as they exist in the main and there was no occasion to take the trouble and incur the delay of surveying in, and afterwards drawing and shading, every trifling change of level in the sands.

As they exist now, they are quite sufficiently and clearly shewn for any practical purpose or argument.

Comparing fig. 1 with fig. 3 it is satisfactory to observe how much more parallel the course of the river's constant channel is now to the revetment than it was in 1856, when the spur A. B. was built, and that while the point E. (the Lall Bagh) was in that year, I may say, below the mouth of this constant channel and the point it impinged on the revetment, it is now some distance above, or up stream of, where the waters of this channel intermingle with those lying at rest under that work.

18. The position of the spur I have just built is shewn on fig. 3 and lettered C. D. By its erection, I hope to carry on the high sand bank caused by the spur A. B. to below the Collector's cutcherry, vide Plan No. 1, and which is just now opposite the mouth of the dry weather

channel of this year, further I trust that the river's constant channel will be, next year, by the erection of the spur C. D., parallel in the main to the revetment, until it clears it at the Salt Golah bastion, marked × on the Plans of Plate 1.

My efforts may not be crowned with the complete success I hope for. Things are just now in about the same state as a dam, of which one has built two-thirds of its length, and your efforts are directed to its entire completion or closing, often a difficult operation; but judging from the results attained by the building of the spur of 1856, I have every reason to hope that the one just completed will be attended with like improvements.

The position it has been erected in I chose chiefly, because I dreaded to place it further towards the river's dry weather stream, lest in flood time, the sand banks, it might create, would push, as it were, the deep channel over towards the head of the Kookye, and so open up and erode the large bar of sand now lying across that river's head. If such occurred, the Pooree district would receive an extra supply of flood water from the Katjooree. It was my especial wish to avoid the risk of such an occurrence. The "spur" I have just built, may be, as I call it, "bullied" a little by the water flowing along the revetment and passing off at the points E. and F., but my expectation is that this will be mitigated, if not prevented from occurring at all, by the silting up of the sands along the line of the spur before the water flows in any strength along the revetment; in fact that the silting up the spur will cause along its site will put a stop to any mischievous eroding flood stream near the revetment wall.

19. Upon plate 6 is depicted the section of the river's bed along the line of the spur A. B. to opposite the Lall Bagh and thence to the point F. vide plate 5, fig. 3 or opposite to where the spur of 1858 has ended. Along the same line a section taken this season is also plotted, the darker shade of brown showing the silting up from the period the spur of 1856 was built to the present. I think this result will be allowed to be very satisfactory.

A section along the "spur" C. D. has also been drawn by me, the bed of the river upon which it was built lately is clearly marked, and I consider that by the building of this "spur," I shall carry on the high sand bank from the point C. to D. or near to it, and that the deposited sand will spill out, down stream of the point D. and so fill up and divert

into a line more parallel to the revetment the river's present constant channel, besides I expect that the slope of the new sand bank which shall be, I trust, created on the line C. D. will extend its slope quite into the toe of the revetment at the Collector's cutcherry and down to the bastion at the point S., vide plate 1, figs. 1 and 2, filling up the pool which still exists between those points as depicted on the plate I mention.

20. On plate 6, I sketch a side view of the spur I have just built, also a plan and end view of it. It is 1923 feet long and consists of a double row of piles driven 3 feet apart from centre to centre, and with a width of 3 feet spur between the rows. These piles averaged 15 feet long and 8 inches in diameter at the head. They were driven 7 feet into the sandy bed, and according as a length of two or three hundred feet was completed, the space between the rows was filled up for a height of 6 feet with facines of brushwood firmly packed and treaded down by the work people; further the top has been bound tightly down by coir ropes crossed from pile to pile as shewn on the plan of the spur, and the whole was rendered very firm and secure. I did not attempt to weigh down the facines with stones, as I found it would be very expensive to do so, and that no commensurate advantage would be gained. The result proves I was right, for although portions of the "spur" have been quite covered by a low rise we have lately had in the river, none of the brushwood bundles have shewn any inclination to rise up, float away, or resist their being confined within the original space allotted to them.

20½. The spur is best described as a continuous wall of brushwood bundles 7 feet high over the sandy bed of the river and 3 feet thick, placed and tied down securely between a double row of piles, these latter having been driven 7 feet into the sand, leaving 8 feet over the river's bed to support and enclose the brushwood facines and arrest the flood of the river, charged as it will be by quantities of sandy particles anxious to deposit themselves when meeting with an obstruction to the flood's free flowage, and that will tend to lessen the velocity of the stream at the point of, I may say, contact.

21. This work was all executed last April and during the first week of May, during which time the river was very low and the site of the "spur" quite dry, I am therefore at the present time unable to describe the action such a work will cause in the river when the floods rise.

22. I can only express my belief, and I see no reason to doubt, that it will be proved as useful as its predecessor of 1856, and though

that of this season has not the great reservoir to fill up along the revetment's base, still it has room to create a most useful sand bank on the low sands it has been built upon, vide plate 5, fig 3.

23. To assist the action of the spur I have placed bars of brushwood, or *dams*, may be the better term, to run across the deep pool from a little above the site of the cross section J. J. and from near the end of the spur C. D. down to S., vide plate 1, at various distances according as the depth of the water or the state of the revetment's foundations led me to choose the site for these dams and which are from 100 to 200 feet apart.

They consist of a mass of brushwood formed of large sized bundles composed of 3 or 4 similar in size to those used in the filling in of the spur. In the centre I placed one or two stones, according to their size, and tied the brushwood round them firmly with 3 coir ropes, one at each end and one in the middle. The bundles are about 5 feet long, and 2 feet in diameter in the centre, at the ends 12 inches or so.

24. I have taken sections perpendicular to the line C. D. at 4 or 5 points, these when compared with those that I shall take at the same points after the floods of this season will, with the longitudinal section along the line of the " spur" taken when I constructed it and the one to be made after the floods, show at once what amount of silting up its construction has engendered. Cross sections can as before be taken at the points they have been measured for the past 4 seasons, and the whole will present a register, clear and explicit, of what our brushwood operations have effected in the Kutjooree's channel near the Lall Bagh.

25. My accounts of the brushwood operations of this year have not yet been made up, as the operations for the sinking of the brushwood bundles and the repairs of the spur, are still in progress.

I find, however, that the spur I have just built has cost about 5 annas per foot forwarded : it is 1923 feet long, so that its cost will be Rs. 600-15.

26. The one constructed in 1856 cost 8 annas per foot forward. The difference I have said, viz. 3 annas per running foot has been owing in part to the fact that the spur built this year was erected during the dry weather, while that of 1856 had to be constructed in the water. The great saving effected, however, was in the pile driving. The engine I found in use in Cuttack could only drive 24 piles per diem with 16 men ; I had made a light ringing or tail engine, and with the assistance of 12 workmen succeeded in driving 50 piles per day on the average.

This cheapened the work considerably. I paid at first the same rate for the brushwood bundles that had been given in former years and which was Rs. 1-7 per 100 bundles landed in Cuttack.

By enquiry and looking out for contractors I have got the same quantity supplied to me at Rs. 1-1 per 100 bundles: this is also a great saving.

27. Stones and ropes are the chief expense in making the large bundles for the construction of the dams along the base of the revetment, to catch the sand in flood time, cause it to deposit itself between these dams, and fill up the intervening space of deep water, along the base of the revetment wall.

28. The component parts of 100 large bundles for sinking and building the dams are as follows.

300 of the small-size, such as were used to fill in the spurs.

150 coir ropes.

100 stones averaging 1¼ cubic feet each.

The cost will be, 300 bundles at Rs. 1-7 each per cent.,	4	5	0
150 ropes at Rs. 1-4 per cent.,	1	14	0
Drawing from Fort Barahattee 100 stones,	0	11	0
Digging up some in fort,	0	12	0
Tying up and placing in boat for sinking,	0	12	0
Carriage of 100 stones from top to bottom of revetment,	0	2	0
Total, Rs.	8	9	0

But as I found a large quantity of loose stone along the revetment wall and in Fort Barahattee the item of 12 annas will be reduced to 2 annas (for putting them on the hackeries) in the one case, and totally in the other.

So that where I got stones near the revetment wall, the cost of 100 large bundles will be reduced to

300 small bundles,	4	5	0
150 ropes,	1	14	0
Tying bundles &c. and placing stone in the boat &c.,	0	12	6
Coolies for collecting 100 stones about,	0	5	0
Total cost of 100 large bundles, ...Rs.	7	4	6

The mean cost has been therefore Rs. 7-14-9 per hundred bundles, but at the present and reduced price of the smaller ones is only Rs. 6-2-6.

I have executed this brushwood work at all these rates, the higher when I commenced, but very soon after I got the work done cheaper from the causes I have stated.

29. After this season's floods subside, I shall report on the effect of the works just completed, stating the cost of them in detail, if such is required, and at the same time I hope the results attendant upon their execution will be as favorable as indeed there is every reason to suppose it will be.

30. Since commencing this Report or explanation, a slight rise has taken place in the Katjooree, the water standing now at 104.40 or nearly 9 feet higher than it was when the spur was completed. If the section on plate 6 is referred to, it will be seen that just at the commencement of the spur C. D., the bed of the river is very low, lower than any other point along that line.

Here the water as it rose headed up and a portion of the brushwood and piling work was carried away, I should say for about 150 feet in length. The sand in this spot is very soft having only been deposited last year and is more like a quicksand than a pure sandbank.

It could not resist therefore any pressure, and the spur built upon it gave way at the base, the piles and brushwood being lifted up and carried away some distance.

Since then I have repaired one half of the gap, I do not at present contemplate closing it, besides it would be very difficult to do so from the strong flow of the water through the opening and the loose nature of the sand.

I think of driving a single, or it may be a double, row of piles across it so as to check the force of the current; but even this I may not do if the present satisfactory results from the opening of the breach continue and which are, that the water after passing through the gap in the "spur" with a certain high velocity, loses it at once and spills out into a quiet lazy stream, flowing over towards the revetment, consequent on this, the sand it held before it passed through the spur deposits just where it should, so that the occurrence of this accident has been followed by beneficial results.

31. If a *flood* had risen, the accident could not have occurred as

the water would have flowed down the river on both sides of the "spur," at once placing it like a splitting dam in the stream and upon which there is no pressure. However, that occurrence must soon take place, as the season is well advanced.

It was the water flowing from the river's constant channel along the low sands (just at the site of the breach) and towards the revetment, that caused the work to give way, as no flood water can, from the height of the sands along the revetment, up stream of the Bellevue guage, flow in that direction until it rises to 110′ or 111′ over datum.

32. But this breach is not to be regretted, as the result of its occurrence is a present benefit, and when the water does up-lift to the level I state, I do not at all anticipate that the gap will affect the action of the "spur." It is 1923 feet in length and will not feel the existence, when the water flows at both sides of it, of a gap only 75 feet wide.

From C. T. BUCKLAND, ESQ., Junior Secretary to the Government of Bengal, to the Officiating Secretary to the Government of India, Department Public Works, Fort William,—(No. 2700, dated the 28th August, 1858.)

SIR,

I AM directed by the Lieut.-Governor to forward, for submission to the Supreme Government, the accompanying copy of a letter* from the Officiating Chief Engineer, L. P. and of one from the Superintendent of Embankments, together with the enclosed Report in original and the set of illustrative plans (7) and sections drawn by Mr. Civil Engineer Armstrong to shew the improvements made in the bed and channel of the Katjooree river, near the Cuttack Revetment, by the brushwood operations which have been carried on since the year 1855.

* No. 2967, dated 17th inst.

2. Mr. Armstrong's Report is approved by the Lieut.-Governor, who entirely concurs in the commendation which the Officiating Chief Engineer and the Superintendent of Embankments have bestowed upon the ability and care which Mr. Armstrong has displayed.

3. With your reply the return of the original documents is requested.

From MAJOR R. STRACHEY, Officiating Secretary to the Government of India, to C. T. BUCKLAND, ESQ., Junior Secretary to the Government of Bengal,— (No. 4846, dated the 1st October, 1858.)

SIR,

WITH reference to your letter No. 2700, dated 29th August last, I am directed to convey to you an expression of the satisfaction with which the Government of India has read Mr. Armstrong's Report on the operations carried on since the year 1855, in the Katjooree branch of the Mahanuddy River, for diverting the stream from the city of Cuttack. The account of these operations and the drawings to illustrate them, are very clear and most creditable to Mr. Armstrong.

2. Mr. Armstrong's original Report and Plans are herewith returned.

From C. T. BUCKLAND, ESQ., Junior Secretary to the Government of Bengal, to the Officiating Chief Engineer, L. P. Fort William, (No. 3321, dated the 27th October, 1858.)

SIR,

YOUR letter, No. 2967, dated 17th August last, and the original Report, by Mr. Civil Engineer Armstrong, to which it gave cover, on the brushwood operations which have been carried on since the year 1855, in the bed of the Katjooree River, having been submitted to the Government of India, Public Works Department, with an expression of the Lieutenant-Governor's approval of the Report, I am directed to forward herewith, for your information and communication to Mr. Armstrong, a copy of Officiating Secretary, Major Strachey's reply,* intimating that that Government has also perused the account of the operations with satisfaction.

* No. 4846, dated 1st October, 1858.

2. The original Report and Plans which accompanied your letter are herewith returned.

CONSTRUCTION

OF A

STONE GROYNE OR SPUR AT NARAJ,

AT THE HEAD

OF THE

MAHANUDDY DELTA.

From MAJOR R. STRACHEY, Officiating Secretary to the Government of India, to A. R. YOUNG, ESQUIRE, Secretary to the Government of Bengal,—(No. 1837, dated the 23rd April, 1858.)

SIR,

I AM directed to transmit for the consideration of the Hon'ble Lieutenant Governor of Bengal, copy of a letter received from Colonel A. Cotton, suggesting certain operations to be undertaken on the Mahanuddy near Cuttack, as of urgent necessity.

2. The Government of India observes, that Colonel Cotton proposes that a sum of twenty thousand Rupees should be placed at the disposal of Captain Short, the Officiating Superintendent of Embankments, to carry out the proposed works which are explained, generally, to be the extension of a groin already begun, and the improvement of the minor piling and brushwood work near Cuttack. The Hon'ble the President in Council directs me to remark that, as no details of the objects of these works have been submitted by Colonel Cotton, no opinion can be formed as to their necessity, but if, on enquiry, the Hon'ble Lieut.-Governor is satisfied that the works are requisite, there will be no objection to his authorizing, without further reference, the disbursement of the sum named by Colonel Cotton. At the same time, the Government of India would be glad to receive, at as early a date as is possible, a succinct account of what it is that the Engineers propose to execute.

3. The Government awaits, with interest, Colonel Cotton's promised Report.

From COLONEL A. COTTON, Comt. Madras Engineers, to LIEUT-COLONEL R. STRACHEY.

SIR,

IN obedience to the orders of the Government of India, received through that of Madras, I have the honor to report that I have visited the head of the Mahanuddy Delta, where I met Captains Short and Harris.

I am preparing a report upon this subject, which will take me some time, but in the interim I think it incumbent on me to lose no time in

stating that, whatever further is done, there can, in my opinion, be no possible question about the necessity of *immediate* operations at and below Naraj, where the alluvial country begins.

I need not go into any detail on this point, because I most fully concur in Captain Short's view of the matter, as given in his various papers. The main points in the case I would put in the following way.

1. The cause of the special evils of late years, both as respects the danger to the town of Cuttack, the destruction of the embankments, and the desolation which has fallen upon the southern portion of the Delta is owing to the change which has taken place in the head of the Katjooree, one of those changes which continually occur in all Deltas which are neglected.

2. It has been a most grievous mistake that this was not attended to, the moment the change commenced.

3. The main remedy must be applied at this spot. Even now, after the mischief has been allowed to run to such a length, the expense of correcting the state of things so far as restoring them to their former state will not be great.

4. The trifling works already executed, viz.: a small groyne or spur of loose stones extending from Naraj hill, and brush and pile work near Cuttack, have been perfectly successful so far.

5. It must be the greatest mistake to lose another season, on every account, for unknown mischief may be done next monsoon, both to the town of Cuttack and to the other country below, and it must be productive of additional expense.

There is, in my opinion, therefore only one thing to be thought of, viz.: the securing the small remainder of the present season, and for this end, I beg most strongly to urge that without waiting for any further documents, the sum of 20,000 Rupees should be placed at the disposal of the Superintendent of Embankments, with authority to apply it at once in the way that he thinks will produce the most effect, considering the shortness of the time. The main work will be the extension of the loose stone groyne already begun, with some minor works such as pile or brushwork near Cuttack, clearing the grass, &c. from the islands in the head of the Mahanuddy, &c. In this way, I have no doubt that the turning of the main body of the water back to that river (which has already commenced as the effect of the short spur) will be greatly promoted this season.

My opinion is, that there can be no room for doubt whatever on these two points, viz.: 1st. That not a day should be lost in pressing on those works. 2nd. That they are essential, whatever further operations are decided upon.

In my report, I shall endeavour to shew that a complete system of works similar to those in the peninsular Deltas, viz.: 1st. To regulate the river floods. 2nd. To provide constant irrigation. 3rd. To carry off the local rains, and 4th. To afford water-carriage to every village, are imperatively called for.

From C. T. BUCKLAND, ESQ, Junior Secretary to the Government of Bengal to the Officiating Chief Engineer, L. P.,—(No. 1186, dated the 28th April, 1858.)

SIR,

WITH reference to the accompanying copy of a letter from the Officiating Secretary to the Government of India in the P. W. D. No. 1837, dated the 23rd instant, and of its enclosure, relating to certain operations which Col. Cotton suggests should be undertaken at once on the Mahanuddy, near Cuttack, as a matter of urgent necessity, I am directed by the Lieut.-Governor to request that you will submit, in communication with the Officiating Superintendent of Embankments, a succinct account of the proposed operations, for the information of the Government of India, as called for in para. 2 of Major Strachey's letter.

2. In the meanwhile the Lieut.-Governor authorises the commencement of these works, within the proposed limit of Rs. 20,000, and requests that you will issue the necessary instructions on the subject to the local Engineers, who, it is presumed, are acquainted with Col. Cotton's views.

Copy of this correspondence forwarded to Col. Cotton for his information.

From CAPT. C. B. YOUNG, Officiating Chief Engineer, L. P. to the Secretary to the Government of Bengal, Fort William,—(No. 2106, dated 13th July, 1858.)

SIR,

WITH reference to your letter, No. 1186, dated 28th April, 1858, I have the honor to submit a copy of the Superintendent of

Embankments' letter, No. 681 of the 30th ultimo, with its accompanying sketch, explaining the nature of the operations undertaken at the Delta head of the Mahanuddy, under the sanction accorded to an expenditure not exceeding 20,000 Rupees, and to state, that, as a detailed estimate for such works cannot be prepared with accuracy, I hope that the description given by Captain Beadle of the proposed works, will be accepted in lieu of an estimate. They appear to me to be of the nature contemplated by Col. Cotton.

2. The return of the original sketch is requested.

From the Superintendent of Embankments to the Officiating Chief Engineer, Lower Provinces,—(No. 681, dated Midnapore, 30th June, 1858.)

SIR,

WITH the aid of the accompanying Sketch Map, I think that a clear idea may be given of the operations undertaken at the Delta head of the Mahanuddy, under the sanction accorded to an expenditure not exceeding 20,000 Rupees, as urged by Col. Cotton.

2. The Government of India in No. 2046 of 12th October, 1855, sanctioned the collection of large blocks of stone, for the purpose of providing the heavy material, necessary to carry out the river bed works in the vicinity of Cuttack, then as now, under consideration.

Received with your docket, No. 4344 of 22nd November, 1855.

3. I directed Lieut. Harris to proceed with this collection, and ordered him to stack the stone on the river's bed in continuation of the living rock at Naraj, forming a heavy mole, and directing the stack longitudinally in the line that would act most advantageously upon the set of the river (which is towards the Katjooree) sending the waters down the Mahanuddy Channel.

4. This was virtually carrying out for a short length the formation of the spur which Lieut. Harris wanted to construct.

5. I reported my proceeding to the Chief Engineer, and defended the measure by the argument "that it was cheaper to deposit the material there than on the actual bank, cheaper also to remove it, if it should be required elsewhere, it also being certain that whatever be done, Naraj is the heel of the work that has to extend into the river bed."

6. A stop was put to the work, as it was considered that, being

stacked so as to become at once useful, I was going beyond the authority received, which was only for the collection of materials pending sanction to a well considered report and project.

7. The "small groyne or spur of loose stones extending from Naraj Hill" adverted to in Col. Cotton's 4th para. as having been "perfectly successful so far," is the stone material collected and stacked as above described.

8. This loose stone groyne is now to be extended, and I hope by this time a fair progress has been made, the length when we again stop the work will probably be about 500 feet, and the Executive Engineer (Captain Harris) will watch carefully the effect of the spur at every foot of length added, with reference to the alterations it makes in the set of the river.

9. He will further aid these changes by preparing the shoals at the head to be cut through and torn up by the currents thus directed upon them, that is to say, he will first establish a cause, and then facilitate the action of its effect, adding to, and increasing both, till the desired result of drawing off the main volume of the waters down the Mahanuddy's Channel is effected, or till the limit of the expenditure authorized has been worked up to, or till as much work has been done as time and the season will permit of his carrying on with advantage.

10. The brush and pile work near Cuttack adverted to in the same para. of Col. Cotton's letter, have been carried on in another locality, and with a different object.

11. Captain Short when Officiating Executive Engineer of Cuttack, alarmed at the set of the Katjooree waters upon the revetment, and their cutting action, which undermined the wall, diverted the current with brushwood, and made a cut through the sand in the bed of the river to lead the waters parallel to, instead of against, the wall. Lieut. Harris who succeeded to the charge in 1855, has carried out a systematic series of brushwood operations for which in each year a sum has been specially brought forward. This work is now well understood, and is executed most satisfactorily.

12. I trust the above report will supply the explanation of the operations it is proposed to carry on with the 20,000 Rupees granted by His Honor the Lieutenant-Governor of Bengal for these purposes on Colonel Cotton's recommendation, called for in the 2nd para. of the Government of India's letter, No. 1837, dated 23rd April, 1858.

From C. T. BUCKLAND, ESQ., Junior Secretary to the Government of Bengal to the Officiating Secretary to the Government of India, Department, Public Works, Fort William,—(No. 2206, dated 19th July, 1858.)

SIR,

WITH advertence to the concluding sentence of the 2nd para. of your letter No. 1837, of the 23rd April, last, I am directed by the Lieut.-Governor to submit, for the information and approval of the Supreme Government, the accompanying copy of a letter* from the Officiating Chief Engineer, Lower Provinces, giving cover to a communication from Capt. Beadle, the Superintendent of Embankments, describing the nature and extent of the operations which it is proposed to execute at the Delta head of the river Mahanuddy under the sanction accorded by the Supreme Government to an expenditure not exceeding 20,000 Rupees for the work.

* No. 2106, dated 13th inst. and one enclosure.—(Sketch in original.)

2. The proposed operations appear to the Lieut.-Governor to be judicious.

3. With your reply the return of the original sketch is requested.

From MAJOR R. STRACHEY, Officiating Secretary to the Government of India, to C. S. BUCKLAND, ESQUIRE, Junior Secretary to the Government of Bengal,—(No. 4000, dated the 20th August, 1858.)

SIR,

IN reply to your letter, No. 2206, dated 19th ultimo, I am directed to inform you that the Hon'ble the President in Council has been pleased to approve of the operations proposed by the Superintendent of Embankments to be executed at the Delta head of the river Mahanuddy, under the sanction accorded to an expenditure not exceeding Rupees twenty thousand.

2. I have to request that the results of these operations may be reported to this department.

3. I beg to return the original sketch of the work as requested.

From CAPTAIN C. B. YOUNG, Officiating Chief Engineer, Lower Provinces, to the Secretary to the Government of Bengal,—(No. 7516, dated the 16th February, 1859.)

SIR,

IN continuation of my letter, No. 2106, dated 13th July, 1858, and as directed in your Office letter No. 2650, dated the 27th August last, and its accompaniment, I have the honor to submit an original letter A. dated the 7th current, with its accompanying Drawings,† &c., from Captain J. C. Harris, Surveyor, Cuttack Rivers, reporting the result of the operations carried out at the head of the Mahanuddy Delta.

† Nos. 790 to 797 of 1858-59.

2. It would be premature to express any opinion yet on the effects of the spur at Naraj, it may be sufficient to point to the conclusion of paragraphs 3, 10 and 11 of the report, as exhibiting the general changes in the river bed of late.

From CAPTAIN J. C. HARRIS, Surveyor, Cuttack Rivers, to CAPTAIN P. BEADLE, Superintendent of Embankments, Lower Provinces, —(No. A. dated the 7th January, 1859.)

SIR,

IN the Secretary to the Government of India's letter, No. 4000, dated 20th August last, I was called upon to submit "a report on the results of the operations carried out this (the past) year at the Head of the Mahanuddy Delta."

2. The report was doubtless called for under the belief that these operations have been of a very varied character, such as, the construction of brushwood spurs on a large scale calculated to effect the dispersion of shoals in the Delta head, clearances of grass and rooting up of jungle over large areas, to assist to the same end, the closings of old objectionable channels by artificial means and opening out of new preferable ones, &c. &c., such operations being supposed, I imagine, to have been conducted among a number of islands of low levels, topped by a trifling rise of the river. Such low shoaly islands capable of quick removal by the joint agency of the flood's power and the skill of the Engineer, might, from Colonel Cotton's letter on the subject, be supposed to form

the characteristic features of the Delta head, but, as you are aware, the actual features are huge islands generally as high and in many parts higher than the banks of the river, islands such as a century's labour would not suffice to effect the entire removal of, not that such entire removal is either necessary or desirable, I would remark.

3. To have attempted the wholesale dispersion of these imagined shoals and actual huge islands by such means as those noted above, would (however simple their dispersion may look on paper) have been equivalent to have recklessly thrown into the river so much of the small sum granted me in Secretary to Government Bengal's No. 1186, dated 28th April last. No such ridiculous attempt has been made during the past season, but the funds placed at my disposal, with the exception of a very trifling amount expended in clearing grass and rooting up jungle from a very limited area and in a particular line, that of the "Doob-lesur channel," have been devoted entirely to the extension of the Naraj rough stone spur.

4. I cannot imagine that I should be expected to report at present any results of this work's so partial construction, only 1-20th part having been executed up to the end of the past flood season, and 1-10th only having been done up to date; I think therefore that I shall be acting up to the spirit of the orders under which I make this communication, if I give here a retrospective view in outline of the state of matters at and in the locality of the Delta head, existent in 1855, when I first drew the attention of Government to it; if I follow this up by a brief narrative of the operations of each succeeding year (the past inclusive) and their *particular* results; and if I point to the main or *general* result of all, as evinced by comparison of the present with the past conditions of the Mahanuddy and its branch, the Katjooree, near the Delta head. The review of these operations and their results having appeared to myself most satisfactory, I cannot think but that it will be equally acceptable to the Government of India. Though matters of this kind must be seen to be thoroughly comprehended and appreciated, the general bearings of facts to which I can point are so manifest, that the main points of improvement will be readily reached through the medium of this brief report and the illustrations hereunto appended.

State of the Delta Head in 1855.

5. The first plan on the above subject ever submitted by me to Government was a "diagram of comparative daily rises and falls of the

Mahanuddy and Katjooree Rivers." This document *(vide* extract in Plate I. month of June) showed the dry weather level of the latter river to be 5 feet lower than that of the former on the opposite side of the town of Cuttack; and from this circumstance, I argued that the Katjooree had acquired an undue *general* depth of bed, I subsequently submitted other plans and sections, drawing the attention of Government to the undue depths of that river at *particular* points, to hollows existing immediately under the foot of the Cuttack revetment wall of depths of 20, 30 and even 40 feet. Lastly, I pointed to the main channel of this river bearing dead into the revetment *(vide* Plate VII.) Referring to my report part I. for minor points affecting the safety of the *town*, I would instance the above as speaking for the state of danger in which it was in 1855. The state of the Delta head above the town, upon which depends the distribution of floods in the *district* was equally unsatisfactory in the year named, the deep channel of the Mahanuddy lying *(vide* Plate VII.) under the right bank of the narrow neck at Naraj favoured the silting up of the Mahanuddy branch of the parent stream and the opening out of the Katjooree branch; operations *precisely the reverse* of those desirable, in either case the former was becoming, year by year, less efficient as a channel of discharge during floods, the right bank of the latter was eroding, and this action was threatening the destruction of the Pooree district. I need say no more of the state of the Delta head in 1855, and will proceed to consider the operations of succeeding years set on foot with the avowed object of remedying the above evils of all kinds.

Operations of 1855 *and their results.*

6. These were confined to throwing bundles of brushwood weighted with stones into the deep hollows under the Cuttack revetment wall, which have been spoken of in paragraph 5, the result of which operations being the silting up of the hollows in various large amounts up to 30 feet of raising produced in the bed of the river at the points in question.

Operations of 1856 *and their results.*

7. In this year a brushwood spur was constructed in position shewn in Plate VII. result of which was a twofold one. Further silting up of the hollows under the revetment wall took place, and the line of deep channel of the river was diverted from a course dead on to the revetment wall to a very favorable one, parallel to this city protective work.

Operations of 1857.

8. Almost nil, owing to my absence from Cuttack on duty in the N. W. Provinces. Minor operations such as those of 1855 were carried on, but no spur work as in 1856.

Operations of 1858 *and their results.*

9. These were of two distinct kinds, 1st the construction of a brushwood spur in the Katjooree bed on the south side of Cuttack, by Mr. Armstrong, C. E. (*vide* Plate VIII.)

2*nd*. The construction by myself of a portion of the rough stone spur at Naraj (*Vide* Pl. III. V. and VI.) The result of the former work, though extremely satisfactory in point of the silting up of the channel under the revetment wall in the localities of the "Lall Bagh" and the "Cutcherry," which has been enormously in excess of the deposit caused by the brushwood spur of the year 1856 (*vide* Plate VII.) is in another respect the reverse of satisfactory, inasmuch as the line of deep channels is far less happily situated now than it was prior to the operation of the spur of 1858; neither Mr. Armstrong nor myself looked to being taken in flank, as Plate VIII. will show us to have been (I say "us," for although I neither laid out nor constructed the work, yet it met with my entire approval when carried out, and I would share with my zealous co-operator Mr. Armstrong, failure and success alike), nor did we look to boats being allowed to cross our newly formed sandbanks, at the critical period of subsidence of floods, which passage to and fro of boats led to the formation of the gap C. (*vide* Plate VIII.) if not to that of the less important ones A. and B. also. We, without doubt, fell into the error of attempting further *annexation*, when we might with advantage have placed our spur *higher up in lieu of lower down* than that of 1856, and have thus *consolidated* our first conquests from the river. As an isolated result, the spur of 1858 cannot be regarded but as unsatisfactory, for there is no shutting the eye to the fact that the river, if left now to itself, would, in a season, work back to its original channel of 1855-56; its course having, during the past year, made so much way back towards the same, and this course being favorable to *further* retrograde movement. I am, however, of opinion that if the operations of 1859 turn out favorably, the aggregate result of the two years' work will be immediately superior to that of two ordinary seasons, inasmuch as the silting up, under the revetment has been enormous in the past season, and the experience gained has been most valuable, so that I have only to correct the course of the deep

channel in 1859 to bring the operations of 1858 to ample account, and have in their example, the best guide to enable me so to do.—— In the matter of the construction on the Naraj spur and its result, little can be said beyond what Plates III. V. and VI. will be found to express. Plate III. shows the position of the 1425 running feet which have been constructed up to the end of the past year. Plate V. is a longitudinal section of the work, showing the portions executed in each month, and from which can be readily distinguished the length of 750 running feet, which was exposed to the action of the two floods of the season. From Plate VI. giving cross sections of this 750 feet, taken at every 50 feet from the Katjooree's right bank, the thickness of the work may be ascertained at any point in that length, and the effect of the action of the two floods may be learned readily. It would be absurd to speak at present of results of this half skeleton of a work, a half of which only was exposed to the action of the floods of the past year, as mentioned above. This portion, small as it was, directed the Katjooree's current, however, into the Dooblesur channel (Plate. III.) and caused it to widen and deepen out advantageously, and the elongation of the sandbank below the spur is doubtless an effect of the construction of the spur having been set on foot. As indications of favourable *tendencies* having set in, they may be spoken of as *results*, but results it would be premature to speak of now, and if no new injurious action (prospected in high quarters) of any kind can be pointed to; it were well, I think, to rest contented for the present with the knowledge of this fact. Referring to Sections, Plate VI. it may be noticed on the one hand that the bed of the river on the down stream side of the spur has been scooped out; (this is no unexpected, but the certain action of a work of the kind), on the other hand the same sections show that on the up-stream side sand has been steadily deposited, and that the work has been uninjured in the slightest degree by the action of the flood. Again referring to Plate II. I have to notice the maximum depth of the river in the line of the spur as having increased from 16 to 19 feet during 1858. I can also point to same plate in evidence of increase in depth from 9½ to 16 feet during the two preceding years, when no spur existed, or lastly if between 1856 and 1858 the width of the river increased 600 feet on the line of spur, and has contracted 190 feet in 1858 (*vide* Plate II.) I can charge the spur with no unfavorable widening tendency. No, I can charge the spur with causation of *no unfavorable action of any kind* as yet, and feel quite

satisfied in this fact, and that previously adduced of the work, quarter skeleton as it was during the flood, having presented *indications of powers precisely those which I prospected for the complete work* estimated for by me in 1856.

10. I will now turn to the consideration of the state of the Delta head in 1859, compared with *that obtaining in* 1855.

In the dry season of 1855, there was a difference of 5 feet in the levels of the Mahanuddy and Katjooree—a consideration of Plate I. combined with local knowledge of the rivers, leads me to draw the inference that 3 feet at least of this disparity has been removed. The *general* level of the Katjooree's bed has been raised 3 feet at least by our brushwood operations. Where hollows existed under the revetment wall 20, 30 and 40 feet deep, we have now sands higher by 4 or 5 feet than the water-level of 1855; all hollows, save one, have been silted up entirely. The bed of the Katjooree has in *particular* points also been raised various heights up to 45 feet. The deep channel of the Katjooree ran in 1855 dead into the revetment wall, and thence along the same. In 1859, there is a huge sandbank (Plate VIII.) between the channel and the wall, and the former has no longer the opportunity of undermining and bringing down the latter. In 1855 breaches in the revetment wall were regarded as certain of occurrence. In 1859 they are scarcely admitted to be within the range of probability. In 1855 the set of the Mahanuddy's current was on the right bank of the narrow neck at Naraj. In 1859 it is on the left, and (*vide* Plate IV.) the water on the former side has decreased in depth 9½ feet, while it has increased 7½ on the latter, precisely what was wanted. In 1855, the height of the sand bank at the very head of the Delta opposite Berhampore (*vide* Plate III.) was on the increase, and had continued to increase enormously until the year 1858, during the floods of which the sands have flattened down in a most marked manner. In 1855 the Dooblesur channel (*vide* Plate III.) was shallow and blocked up by island shoals. In 1859 it is found a wider, deep and clear channel carrying a large body of water into the Mahanuddy and relieving considerably the Katjooree branch. In 1855, the sand bank below Naraj extended about one mile below that village. It received no visible addition to its length until the floods of 1858, after the subsidence of which it was found to have extended half a mile further down the river. In 1858, a much larger proportion of the floods flowed into the Mahanuddy branch channel than had been the

case in the year 1855. Direct proof of this will be furnished during the present year, in which I have requested the Embankment Officer to register daily the rise and fall of both branches, Mahanuddy and Katjooree, for comparison with similar observations made in 1855—indirect proof I have already offered in mentioning the sands opposite Berhampore (Plate III.) to have flattened considerably, the set of current to have moved from the right to the left side of the neck of the Mahanuddy at Naraj (*vide* Plate IV.) the head of the Katjooree to have narrowed 600 feet in the past year (*vide* Plate II.) and the level of its bed at Cuttack to have been raised 3 feet at least.

11. I need draw no further comparisons to show how the state of things at and near the Mahanuddy Delta head has improved in between 1855 and 1859, but I have yet to show what part of that improvement is due to *nature*, what to *art*. To nature, in throwing up the sandbank "U" (*vide* Pl. III.) is attributable all but a small percentage of the improvement effected at the very head of the Delta. To art, in combining judiciously the operations of Mr. Armstrong and my own with those of nature, are attributable the many improvements made in the bed of the Katjooree opposite Cuttack—improvements which have far exceeded our most sanguine expectations, and which, as I have said above, must be seen to be thoroughly appreciated, but whose importance I do not despair of being partially recognised after perusal of this simple outline sketch of them; uncoloured and unvarnished, it presents but a dull picture, but its being truthful in delineation of objects as they are, will compensate for this defect, if such it be.

12. Having brought my narrative up to date, it were perhaps desirable to say a word or two, regarding the prospected operations of 1859. It is proposed to continue the extension of the Naraj spur to S. (Plate III.) on the left bank of the Katjooree's cold weather channel. I have *funds*, *establishment* and *time* (up to the period of floods when work is practically suspended) *sufficient*, and *no more than just* sufficient, to make this extension, and carry height of work up to about the level of the river in dry weather. If it be the wish of Government to *further* advance the work *in time specified*, it will be as necessary to place *establishment* at my disposal as *funds*. On the close of the hot weather season's work, again, I shall, unless supplied with an additional grant, be compelled to put a stop to the Naraj spur work entirely. In the matter of brushwood spur operations, I propose for execution by the

Executive Engineer of the Embankment Division, during 1859 two lines, "V. W." (Plate III.) and "XV." (Plate VIII.) The former work will be highly desirable, if with reference to the supply of material procurable, it can be executed *in addition* to the latter work, which being absolutely indispensable, must be primarily arranged for. The object of the former work is to assist in widening the Dooblesur channel, that of the latter to turn the main channel of the Katjooree off its present course, but I need speak no further regarding them, as plans and Estimates based on Memoranda furnished to him by me will be shortly submitted to Government by the Executive Engineer of the Embankment Division, Mr. Rayner.

P. S.—No copy of this document has been taken, and most of the Plates are original drawings, I shall therefore be glad if copies of it be taken in the offices requiring them, and the original be returned to me, of both report and illustrations.

No. 1183.

COPY of the above with the Drawings *in original*, submitted to the Government of India, Department Public Works, for information, in continuation of this Office letter, No. 415, of the 2nd ultimo. The return of the Drawings is requested.

By Order of the Lieutenant-Governor of Bengal.

From CAPTAIN C. B. YOUNG, Officiating Chief Engineer, Lower Provinces, to the Secretary to the Government of Bengal,—(No. 218, dated the 11th May, 1859.)

SIR,

IN continuation of previous correspondence noted on the margin, I have the honor to submit, for the consideration of Government, the undermentioned Drawings and Estimate prepared by Captain Harris, Surveyor of Rivers in Cuttack.

Government of Bengal's No. 1186, dated the 28th April, 1858.
Offg. Chief Engineer's No. 6892, dated the 17th January, 1859.
Government of Bengal's No. 413, dated the 2nd February, 1859.

Estimate (No. 377 Book A. of 1858-59 C. E. O. L. P. with Drawing No. 1124) of the probable expense of constructing a rough stone "groyne" or "spur" at Naraj, amounting to Company's Rupees 52,164.

2. The construction of the spur was commenced in May 1858 under orders of Government on Colonel Cotton's report, a copy of which was furnished from this Office to both the Superintendent of Embankments and Captain Harris.

3. Of the amount of the Estimate, 30,000 Rupees have been already sanctioned by Government in your letters noted on the margin, of which sum Rupees 13,348-14-1 have been expended on the work up to March last, as per abstracts received in the Central Office of Account. The remaining 22,164 Rupees of the estimate, making the total estimated cost of the spur Rupees 52,164, is required to advance the work in the manner explained in my No. 6892, dated the 17th of January last, and its accompaniments.

No. 1186, dated 28th April, 1858, and its accompaniment sanctioned Rupees	20,000
No. 413, dated 2nd February, 1859, sanctioned Rupees,	10,000
Total Rupees,	30,000

4. The specification mentions briefly the object of the work, and the annexed extract (paragraphs 5 to 8) of the Superintendent of Embankments' letter,* forwarding the estimate, shews what has been done up to the present time. The result of the works at Naraj and at the head of the Delta up to January, is given in Captain Harris' report submitted in original with my No. 7516, dated the 16th of February following, since then the spur has been further advanced, as will be seen from the extract of Captain Beadle's letter forwarded, and that Officer has promised that the results of the work shall be carefully watched, and I have requested him to report the further result since Captain Harris' report of January last.

* No. 4023, dated 27th April, 1859.

5. The estimate is approved by the Superintendent of Embankments, and the rates are fair.

No. 1929.

Copy of the above,* together with the estimate and plan *in original* forwarded for the consideration and orders of the Government of India in the Public Works Department, with reference to the letter from that Department No. 2712, dated 30th ultimo, and the previous correspondence on the subject. See Statement accompanying.

* Letter and of its enclosure.

By Order of the Lieutenant-Governor of Bengal.

Extract of a letter, No. 4023 of 27th April, 1859, from the Superintendent of Embankments, to the Officiating Chief Engineer, Lower Provinces.

PARAGRAPH 5. To return to the estimate. The spur has assumed its own form, and it stands as shewn in the Section with steep sides. The aprons will give it stability, and we shall, in a few months, be able to state what the effects of the floods have been upon it.—I was in hopes that the spur might have been doubled in thickness, but this could only be done, the advance being limited, by diminishing the aprons, and they are of greater importance to the stability of the work, which is an experimental one.

6. As an experimental work, it shall be carefully watched and its changes be completely recorded. The office of account can afford you information of the expenditure, rate and quantity of work done up to the 1st March. Owing to the management having been good, the rate is low, but the blocks of which the spur or mole is formed are not very large, they are in fact of all sizes and every detached piece of rock, whether naturally so or by blasting, is boated to the mole and pitched into position.

7. Up to this time the spur has stood well, and it was entirely submerged during the floods of 1858; the work, however, had not then stretched out into an exposed position and was more sheltered than its present end will be.

8. We shall watch the effect of the floods upon the spur, and the result of the spur in directing the waters, with interest and anxiety; and I only wish we had proceeded as far in the solution of the difficulty presented in the enormous excess of the volume of a great Mahanuddy flood over the capabilities of the Delta channels to contain and discharge it, as we have in the distribution of the waters between the two great Delta branches.

From CAPTAIN C. B. YOUNG, Officiating Chief Engineer, Lower Provinces.—(No. 602, dated 21st May, 1859.)

THE following transcript received on the 13th May current, forwarded to the Secretary to the Government of Bengal for information in continuation of this Office letter No. 218 of the 11th idem.

Extract from a letter, dated the 30th April, 1859, from CAPTAIN HARRIS, Surveyor of Cuttack Rivers to CAPTAIN J. P. BEADLE, Superintendent of Embankments.

Facts of the year 1858-59.

2nd Naraj spur, estimated for at a cost of 1,00,000 Rupees in July 1856, sanctioned to the extent of Rupees 20,000, work carried out to the full length of 3,000 feet, at a cost of Rupees 16,000, and a further sum of 2,000 expended in part construction of the apron of the work; 2,000 Rupees left on the 1st May, 1859, for expenditure during that month. The 750 feet running feet of the incomplete work, which were exposed to the action of the flood of 1858-59 sustained no damage therefrom, and caused a satisfactory action to set in—this, indicated by the elongation of the shoals under the Katjooree right bank previously eroded by floods, the lowering of the Mahanuddy shoals which previously had increased in height, and the enlargement of a channel between the two rivers, which was closing rapidly prior to the construction of the spur.

No. 1930.

COPY forwarded to the Government of India in the Public Works Department for information, in continuation of Docket No. 1929 of this day's date.

By Order of the Lieutenant-Governor of Bengal.

PUBLIC WORKS DEPARTMENT.

Estimate submitted by the Government of Bengal for the sanction of the Government of India, with endorsement No. 1929, dated the 30th May, 1859.

Proposition submitted for approval.		Orders by the Govt. of India.	
Description.	Amount.	Register No., P. W. Dept.	Amount sanctioned.
Construction of a rough stone "Groyne" or Spur at Naraj near Cuttack to regulate the waters of the Mahanuddy and Katjooree Rivers.	Rs. A. P. 52,164 0 0	No. 49.	Rs. A. P. 52,164 0 0

Remarks.	
Of the estimated cost the sum of Rupees 20,000 was allowed in the letter from the Government of India, Public Works Department, No. 1837 of 23rd April, 1858, and a further sum of Rupees 30,000 was sanctioned in Secretary Lieutenant-Colonel Yule's letter, No. 2712, dated 30th ultimo, a copy of which has been furnished to the Officiating Chief Engineer, so that the amount remaining to be sanctioned is Rupees 2,164. *Vide* Captain Young's letter, No. 218 of 11th instant and accompaniments, submitted with Bengal Government endorsement, No. 1929 of this day's date.	Sanctioned in supersession of former partial sanctions. The Plan and Estimate returned. Forwarded to the Government of Bengal as No. 4504, dated 2nd July, 1859. H. YULE, *Secy. to the Govt. of India.*

No. 2542.

Copy forwarded to the Accountant to Government of Bengal for information and guidance.

No. 2543.

COPY forwarded, for information and guidance, to the Officiating Chief Engineer, Lower Provinces, with reference to his letter No. 218 of 11th May last, and the Plan and Estimate returned.

By Order of the Lieutenant-Governor of Bengal.

From CAPTAIN C. B. YOUNG, Officiating Chief Engineer, Lower Provinces, to the Secretary to the Government of Bengal,—(No. 1249, dated the 13th June, 1859.)

SIR,

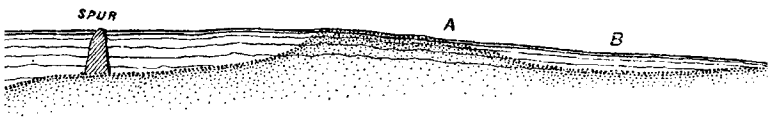
IN continuation of the concluding part of paragraph 4 of my letter, No. 218, dated the 11th ultimo, regarding the Naraj spur, I have the honor to submit for the information of Government, copy of a letter, No. 21, dated the 20th idem, from Captain Harris, Surveyor of Cuttack rivers, reporting the further result of the spur at Naraj since January last.

From CAPTAIN J. C. HARRIS, Surveyor, Cuttack Rivers, to CAPTAIN J. P. BEADLE, Superintendent of Embankments,—(No. 21, dated 20th May, 1859.)

SIR,

WITH reference to your No. 156, dated 17th instant, I beg you will explain to the Chief Engineer, that the spur at Naraj has not, since January last, been exposed to action which could be productive of results of any kind.

2. The *cold weather* level for a long distance above Naraj and some



distance below, is almost *dead* level, so that no more result could be expected, than that which would attend the construction of a jetty in a pond.

3. Directly the river begins to rise, I will record most carefully the results of the action which may set in, and report periodically.

4. The fall of cold weather level between Naraj and Cuttack, was in 1856 distributed between 3 short lengths, as A. B. in diagram, where natural weirs "A" (in section of above diagram) of sand formed and cross the river, and in that year there was *a dead* level for 2 miles above Naraj and below it. I do not know the precise level this year, but it does not differ essentially from the state of things which was found obtaining in 1856. Unless this be explained to the Chief Engineer, it will doubtless be unintelligible to him, that I should have no results to report now. The water at and about Naraj in the cold weather forms practically a Lake.

Office Memorandum from LIEUTENANT-COLONEL C. B. YOUNG, Officiating Chief Engineer, Lower Provinces,—(No. 7658, dated 13th April, 1850.)

WITH reference to the memorandum from the Bengal Government quoted in the margin, the Officiating Chief Engineer has the honor to submit for the information of Government a report with Drawings,* showing the progress made in the construction of the spur at Naraj up to the present time.

No. 404, dated 8th February 1860.

* No. 1005 of 1859-60.

2. The report by Captain Harris is very full and complete. It embraces the origin and object of the spur, the progress made, the effects obtained, and the results anticipated; and Captain Beadle, formerly Superintending Engineer, 3rd Circle, through whom the report was received, requests that it may be printed and circulated as a Volume of "Selections," and in this the Officiating Chief Engineer concurs.

3. It is shown that the work was commenced in June 1858, and a length of 750 feet had been projected before the floods of the year rendered a temporary cessation of work necessary. By the end of the year it had been extended 1,425 feet, and before the floods of 1859, the spur had been extended to the sands of the opposite shore of the Katjooree, or a total length of 3,000 feet, and to a height equal to the dry weather level of the river. Since the rains the heightening of the spur has been carried on vigorously.

4. The quantity of work done in 1858, including 60,000 cubic feet stone previously collected, was 4,35,000 cubic feet, and in 1859, 11,53,000 cubic feet, and the average cost Rupees 1-12-6 per hundred cubic feet.

5. The work set apart to be carried on, during the current year, is the raising of the spur, increasing it to the full section, and the construction of front and rear aprons, and it is expected to complete the work within the amount sanctioned previous to the setting in of the rains of 1860.

6. The result of the spur, as evinced by the guage measurements made during the rains of 1859 as regards three high floods, was to raise the Mahanuddy level in the first flood, thirteen inches; second flood, fourteen inches; and third flood, eight inches, as compared with floods of similar height in the Katjooree in previous years, and since the falling of the river, it has been ascertained that the bed and water lines of the Mahanuddy have been reduced in level eighteen inches.

7. The spur appears to have answered Captain Harris' expectations, and great credit is due to him for the manner in which the work has been carried out.

Report upon the "Naraj Spur," in course of construction at the head of the Mahanuddy Delta, by CAPTAIN JOHN C. HARRIS, Bengal Engineers, Cuttack, 1st February, 1860.

1. Having been called upon to submit a report upon "the result "produced by the above work during the past rainy season," as also upon "the progress made up to the present time in the construction of "it;" and having been obliged in consequence to prepare a set of drawings to illustrate these subjects, I avail myself of the opportunity, which the presence of these illustrations gives me, of extending the scope of my Report, so that in addition to the information called for, it may contain a concise account of the origin, and object of the spur at Naraj and of other interesting particulars regarding it.

2. I shall follow my usual plan of addressing myself to the general, rather than to the professional, reader: looking to the former deriving some advantage from my attempts to render the principles involved in the work, the objects aimed at, or effects already produced by it, as intelligible as possible; and to the latter accepting any apology which

may be necessary for the introduction of matter with which he may be supposed to be fully conversant.

3. When the spur was first designed by me in 1856, the principles upon which the project rested, were not generally recognised. Though I personally felt no doubt of their soundness, I could not do otherwise than speak of the results of the work as problematical, and defer to the opinions which might be formed by other people, on the probable result of carrying those principles into practise. Now, however, practical evidence of their correctness can be adduced, so they may be laid down as matters of fact, not of speculation; I may, therefore, freely offer them for the consideration of the general reader; and this I feel called upon to do with something more than ordinary minuteness; inasmuch as it would appear, that the really simple principles involved in the project, have either been insufficiently explained, or but imperfectly comprehended; judging from the facts of countenance and opposition to my project having been met with in very equal ratios in professional quarters, and of funds for the construction of the work having been supplied, at first, in a manner not calculated to impress me with a high idea of the confidence of the Government in the ultimate success of the work. Both of the above difficulties will be met by my following the course proposed, one on which I will enter at once without further preface.

Extract, Report Part I. Para. 89. "Of the results "of construction of a weir* "such as I propose, I have "spoken as certain, feeling "them to be so; but this "is necessarily matter of "opinion. That they are "certain, however, I have no "hesitation in advancing as "my own."

4. The subject of my Report will I think be most satisfactorily treated under the subjoined general heads.

1. *Origin and object of the Naraj Spur.*

2. *Progress in the construction of the work made up to the end of the year* 1859; *and that prospected for* 1860.

3. *Results of the incomplete work observed in* 1859, *and those prospected of the complete work, both the immediate and eventual.*

I will therefore proceed to consider the "ORIGIN AND OBJECT OF THE NARAJ SPUR."

5. Though the evils which the Naraj Spur is intended to counter-

* In my Report I. I have styled the work a "*weir*," and thenceforth a "*Spur*." It is a "weir" *to the Katjooree River*, and a "Spur" *to the joint waters of that River and the Mahanuddy*.—Should I be charged with truckling to the popular prejudice against "Spurs," I must admit the easier impeachment in this instance.

act had been felt long previously to A. D. 1855; the very extraordinary flood of that year may be said to have originated the work named, which has been proposed as a means of regulating the distribution of flood volume in the two arms into which the Mahanuddy divides immediately after debouchure upon the Delta at Naraj. Disarrangement of distribution was first indicated by a Diagram of the flood of A. D. 1855, (Plate V. Report Part I. on the Cuttack Rivers, or Plate VI. of this Report) which was compiled during that year from a most complete set of* observations made, and submitted by me to Government in evidence of the necessity of close investigation of the circumstances which had produced and might attend such disarrangement. Investigation was promptly ordered by Government to be set on foot, and was duly instituted during the following year. The results will be found in my Report Part I., to which I would refer the reader for facts and arguments adduced during the course of the investigation held, confining myself here to quotation from that document of general conclusions drawn.

6. In regard to the cause of one evil, viz.: the danger in which the town of Cuttack was proved to be, I have observed as follows in Report Part I.

Para. 82. "The cause of existing danger, as I have said above, "is to be found in the town's condition with respect to the Katjooree "river; the direct course, velocity, volume and direction of current, of "which, each exerts almost its maximum of evil."

My investigations had at the time been too limited to admit of my doing more than foreshadow the greater evil, viz. the danger in which the *district* stood, but the quotation of a note (page 44) will show the danger to have been understood, though its precise measure had not as yet been determined.

"I speak solely with reference to its (the Katjooree's) local effect "upon the town of Cuttack; the general tendency of the river being "towards enlargement Southwards; the desolation of the Pooree district "must eventually result unless precautionary measures are taken."

7. In the matter of remedy I have said "Para. 83, a common "remedy there is only one; an alteration of the distribution of the "Mahanuddy's waters, in such manner as to increase the length of the

* Fortunately arranged for prior to the setting in of the floods, not under the hope of learning all that could be learnt of the highest flood ever known, but of learning something of any kind of flood which might present itself.

"path of the current of the Katjooree between Naraj and Cuttack "diverting it the while from the revetment (wall of the town); and "to decrease its (the Katjooree's) volume."

8. I shall be found to have observed further that "(Para. 87.) "By throwing an 'imperfect* weir' (or 'Spur') in the direction "shown in Plate XXV. (of Part I. and again in Plate III. of this Report) "across the head of the Katjooree; and operating judiciously upon its "bed near Cuttack; the subjoined results may be reckoned on as "certainties;

"1st. Improvement of the Mahanuddy's bed due to mild scour "throughout the rainy season.

"2nd. Discharge by the single stream (the Mahanuddy) working "during low floods, of a greater amount of sandy particles than could be "effected by the two working together; and a consequent diminution "of the tendency of the bed of the main stream to rise, owing to deposits "taking place whilst the river runs at small velocities.

"3rd. Enlargement of the channel of the Mahanuddy in its "passage over the Delta's head, enabling it to receive during high floods "the extra volume for the discharge of which the scour of its bed will "fit its lower portions.

"4th. Thereby producing draught in the direction of the main "stream tending to carry the path of the current in high floods consider- "ably beyond Naraj before its division into the two branches† which it "takes; causing a lengthening of the path of current in the Katjooree "between Naraj and the town (Cuttack); and operating favorably upon "the direction of the same, (i. e. of the path of current).

"5th. Changes in length and direction of the path of current, "both of which (would) effect reduction in local (flood) level at Cuttack; "and the latter, a diminution of the main causes of danger, to which "the town now stands exposed; previously shown to be the velocity, "volume, and (unfavorable) direction of the Katjooree River.

"6th. Independently of the indirect reduction of volume and "velocity due to the branch's (Katjooree) practical departure from the "main stream (of the Mahanuddy) lower down than it departs now, and "consequently at lower level; a direct reduction due to the existence "of the weir (or Spur)."

* Vide Note, Page 1.

† "Arms into which it divides" would have expressed my meaning better.

9th. In Report Part I. mention is made of a 7th result prospected, which I quote here merely to show, that "the diversion of "the current of the Katjooree from the revetment wall of Cuttack," forming a part of the remedy suggested, was originally proposed for attainment by other agency than that of the "spur," viz.; by "brushwood operations," and that it should consequently be struck out from the matter now in course of consideration. I quote this 7th result. "7th as a result of brushwood operations the entire silting up of the "Katjooree's channel running under the toe of the revetment wall and "the opening of a less objectionable one in the centre of the stream (or "rather river bed)."

10. The Naraj Spur, then, was originally designed; *generally*, to "lengthen the path of current of the Katjooree river between Naraj and Cuttack," (that is to say, the point of impact of the current on the revetment wall at Cuttack); and to "diminish the volume of the flood in that river;" *particularly* it was originally designed to accomplish certain results, which having been mentioned so immediately above, need not be repeated.

11. Having devoted the above remarks to the "origin and object" of the spur, I would pass on at once, to a consideration of the "principles upon which it was expected to act;" but that what I may have occasion to say on this subject, will be so much more readily comprehended after, than before, certain remarks which I propose to make on the "gauge-measurement of rivers." I have said previously that a diagram compiled from such measurements afforded me the first indications of that dangerous derangement of level in the two arms of the Mahanuddy, which has since become established fact. This same Diagram I spoke of thus in my Report Part I.

"Para. 95. Lastly, I have to notice Table V. appended; the "standard of the movements of the Mahanuddy and its branch (the "Katjooree) whence deterioration or improvement may be ascertained "at any future period."

12. The Diagram of gauge measurements of a river is, as it were, the pulse of a river's system. I hope to show it to be not merely a hidden pulse, such as in a case of human ailment would be indicative of disease to the mind of the medical man, and a mystery to the unprofessional; but a pulse such as might be laid bare by the former to the view of the sick person's relatives; the workings of which they may see into

and understand as well as himself: a pulse by observation of which they might judge for themselves of the state of the patient; and by a comparison of the changes taking place in which, with those predicted by the medical man, they might take a correct measure of the value of his services; and know when to place a confidence which might assist in the saving, or when to withdraw it, to prevent the killing, of the object of their sympathies. When I assign to gauge measurements the important position in a river's system, occupied by the pulse in the human frame, I need offer no apology for the digression which I am now making, in view to pave the way to the comprehension of the subject of the

GAUGE MEASUREMENT OF RIVERS.

13. It would appear perhaps at first sight, that the observation of rivers by means of gauges must be a very simple matter. I fancy I hear it said, "Why, of course, the more water in a river, the higher it "will rise on a gauge, and vice versâ," and that "where premises are so "simple, false conclusions could not possibly be come to." On the other hand, when allowing the above general conclusion to be sound, I not only inform my reader that there is no "of course" in the matter, but that on the contrary I shall have occasion to show, that under certain circumstances the very opposite conclusion is as easily and as correctly deducible; he may be disposed to think, that the measurement of rivers by gauges, must be too productive of paradox to be worth the time spent on the consideration of their indications.

It will save him trouble, if he incline at starting with me on a consideration of the subject, to accept as a fact, what experience has proved to me to be the case, viz.; that so many circumstances invariably offer themselves for consideration in all practical cases of rivers, that conclusions are not to be easily arrived at; though if once drawn on a correct understanding of the circumstances obtaining in each case, there is no reason why they should not be substantially correct, and become extremely valuable.

14. In the hypothetical cases of regular channels, I may readily and infallibly arrive at conclusions as to their movements, from the consideration of their simple gauge measurements; or I may pronounce certain conditions of river to be necessarily productive of certain levels on gauges; this is only so, because I am supposing cases of *regular* channels, in which the circumstances obtaining are *regular* in themselves, and clear of determination; but these conclusions are not such as I can

apply off hand, as never failing rules for rivers having *irregular* channels, saving in a general manner, and as far as I can demonstrate that the movements of the regular and irregular channel partake of similarity. They are useful to me so far in aiding my judgment in respect to rivers, but I must weigh evidence of all kinds, go into many and various circumstances known to obtain, and allow for many even which are only likely to obtain, ere I can reconcile the seeming paradoxes which often times present themselves in practice; and not until after so doing can I draw any correct and valuable conclusions. These, be it observed, cannot be, at the best, of universal application. Their applicability in each particular case, must depend more upon the correctness of the judgment and calculations of the applier, than upon the delicacy and accuracy of the theory to be applied. This is so in most matters; for instance, we are aware what strides the science of gunnery has been making during the last few months in England, but it is affirmed in respect thereof, that where the circumstances involved are so intricate, so constantly altered, and so difficult to be preconceived; the practical working of its theory must always remain more dependent on the skill of the marksman, than upon all the science and ingenuity of the inventor of a new projectile or piece of ordnance. The apparently contradictory results which continually arise are only to be reconciled by one who combines a thorough knowledge of both the theory and practice of the science. So precisely with the theory of river measurement and its practical appliance. However let me not digress further.

15. Referring to Plate X. let me suppose two 15-foot gauges to be set up at points A. and B. (vide Fig. 1,) in the bed of a regular channel or river of very great uniformity throughout, having an equable slope of 1 foot per mile. Let them be supposed to be 5 miles apart, and to have been adjusted to the 5 feet of fall between them, so that the gauge measurement of some small supply of water in the channel, or of the dry weather level in the river, (black shaded in Diagram) at each point, may be identical; say 1 foot on each gauge. Let me suppose too the manifestly possible cases, 1st of the measurement of a 5-foot supply of water in the channel, or of a 5-foot flood in the river, being identical on the two gauges; 2nd of the identity being preserved at the 10-foot level; and 3rd after the failure of supply in the channel, or subsidence of the flood in the river, of the fall in the water level at A to 1-foot, being accompanied by the fall at B to 1-foot also. Further let

this parallelism of measurement be supposed to obtain during a long period, and to be ascertained so to obtain at every rise and fall of the channel or river. In such case the conclusion might safely be drawn that the gauge measurement formed an exponent of the movements of the channel or river, as infallible as could be desired. I started, be it remembered, supposing an uniformity in the channel or river, calculated on general principles to work regularity of rise and fall of surface level, and regularity of gauge measurements; I not only obtained regularity, but such regularity was observed to be maintained; and I had every right to conclude, not only that my river had acquired and maintained a strict regimen, but that my gauge measurements would have indicated change of circumstance, had it taken place. Now let me, referring to Fig. 2 suppose that after the identity of conditions (i. e. of river movements and of gauge measurements) prevailing for a lengthened period, it should be observed that with the water level at gauge C. (corresponding to A Fig. 1,) standing at its ordinary low of 1-foot on the gauge, the water level at D. should suddenly drop 2 feet below the ⊖ of the gauge at that point. In such case whether should I look for failure of the general law, or for alteration of circumstances in the river? In the former case how discard the very indicator of the change! I should prefer the latter alternative, and should look first for change of circumstance in the river bed. I need not look long; for but a moment's consideration shows me, that it were physically impossible for the water level to have fallen the 2 feet below ⊖ of the gauge at D., unless the bed of my channel or river were to have been cut away to some point below it; unless in fact the bed were to have deepened from "a. b. c." to "a. d. f." Further consideration will, as I shall shortly show, lead to the conclusion that excessive volume thrown into the channel or river from some extraneous cause, can alone account for the change effected. Thus gauge measurements will not only have clearly indicated the fact of change, but will have pointed to the particular change effected in the channel or river, and to the cause of the change brought about.

16. It would seem on general principles, that the deepening of the river's bed from "a. b. c." to "a. d. f." would, (other conditions remaining unchanged, as we must suppose them to be) by increasing the slope of the river, add to its discharging power both at C. and D. The discharge then at the former point must be greater from some cause or other at the 1-foot level on the gauge, than it had been previously; and

a volume must pass D. at a level 2-feet under ⊖ of the gauge, excessive of that discharged at 1-foot on the gauge before the change had taken place. Thus though, as I have previously allowed, it is a fair general conclusion, that "the more water in a river the higher it will rise on a "gauge and vice versâ," it appears from what I have said above to be an equally simple and correct one, that "the more a river deepens its "bed and the lower the level of its surface falls, the more water can it "discharge at any given level on a gauge." These two conclusions appear paradoxical, but the paradox is but a seeming one. In the case last supposed my river, at a level 3 feet inferior to that which it was supposed first to have, has been proved to be capable of carrying off more water than when at the higher level because its bed had been cut away and lowered. It will be seen from the above, that a person who should adopt the single general conclusion first allowed, regardless of circumstances obtaining at the time of adapting his conclusions, might err egregiously in supposing the river at its altered level to be discharging less than it had done previously; whilst another impressed not only with the value of general conclusions, but the bearing of circumstances upon their formation, would form a correct judgment as to the relative discharges in both instances. Who then can deny the practical advantages to be gained from simple gauge measurements of rivers, which I have shown to be capable: 1st of "indicating the fact of change "in rivers' states and movements;" 2ndly of "pointing under some cir-"cumstances to the particular change produced," and 3rdly of "guiding "indirectly to the cause of the change observed?"

17. Again, referring to Fig. III. I may observe that precisely the same reasoning as that used above, will lead to the formation of the correct conclusion in the opposite case of a river silted up in its bed from "a. b. c." to "a. e. g." viz.; that "however true it may be, that "the discharge in a river is proportional to the height on a gauge, that "very height may be under some circumstances an indication of the "silting up of the bed; and a ground of argument in favor of diminution "of discharge rather than increase."

18. I might multiply cases upon cases of "seeming paradox" but the instances above given will suffice; and I will therefore request my reader, to direct his attention to an hypothetical case of another kind. I would suppose 2 rivers of equal section at the head, but in other respects similar respectively the one to C. D. and the other to E. F.,

having sections of bed a. d. f. and a. e. g.; to be connected at their heads and to be supplied with something more than double the volume of water calculated to raise the level in a river such as A. B., to 10 feet on each of its gauges, at A. and B. Owing to the relatively superior and inferior slopes of bed obtaining respectively in the last named rivers C. D. and E. F., the water line of the rivers, if they were unconnected, would stand in the former, at (say) 9 feet at C., and 7 feet on the gauge at D.; and in the latter river, at (say) 11 feet at E., and 13 feet on the gauge at F.; but in consequence of the connection at the head which I have supposed, the water level at that common head would stand probably at about the level which half the volume, would rise to in the river A. B., viz.; 10 feet on the gauge; the measurement of the deeper river C. D., would probably be 8 feet on the gauge at D.; and the level at F. of the river E. F. would probably be as high as 12 feet on the gauge at that point. The discharge of the river C. D. would manifestly be considerably greater than that of the river E. F. Now a consideration of merely the facts, 1st of "the gauges D. and F. being set up at precisely the same level, and at precisely the same distance from the common head," and 2ndly, of "the gauge reading at D. being 8 feet, whilst that at E. was 12 feet;" might lead to the conclusion (which cæteris paribus would be a correct one) that the river E. F. contained the larger volume; a conclusion which would be directly opposed to fact: whereas a consideration of the above facts in connection with the *circumstances obtaining* in both channels would certainly lead to the opposite and the correct conclusion, viz. that the discharge in the river C. D. is greater than that in its fellow.

19. I trust I have been enabled to show from the remarks made upon the above hypothetical cases, not only that conclusions as to the state and movements of regular channels, or rivers of uniform character, may be readily and infallibly arrived at from the consideration of gauge observations and vice versâ; but that these conclusions may be applied successfully to the cases of ordinary rivers if due judgment be exercised the while, I will therefore proceed to apply the above principles to the case of the Mahanuddy, without further explanation.

20. As I have said previously, a Diagram of these useful gauge measurements, the value of which I have just descanted freely upon; first indicated to me the disarrangement of level in the two arms of the Mahanuddy river, the particular case of which will be seen in the sequel,

to be parallel to that in Para. 18, of the two rivers C. D. and E. F. connected at their heads C. and E. The main difference between the actual and hypothetical cases will be found to lie, not in the difference of circumstance obtaining in the real and supposititious rivers, but in the fact of the real gauge observations of the Mahanuddy and its arm the Katjooree, having been made at points distant respectively 9 and 6 miles from the point of departure of the latter from the former river; whereas in the hypothetical case I have supposed the distances of the gauging points from the common head to be identical. Requesting my reader to bear in mind the position of the gauges in the two arms of the Mahanuddy river, I will endeavour to place before him the indications of the states and movements of those rivers which the Diagram (Plate V. Report Part I. Cuttack Rivers or Plate VI. of this Report) of gauge measurements of the Mahanuddy and Katjooree conveyed to me. I will do this, step by step, precisely in the order in which the indications originally fell under my own notice; and I will follow them up to the conclusions which I came to, and which, I would observe, were found strictly in accordance with subsequently ascertained fact.

21. The first fact presented to my notice as early as the 24th June, 1855, was that "the lowest level of the Katjooree river (attained on date named) was 4 feet lower than that of the Mahanuddy on the opposite side of the town of Cuttack." Now the lowest level of the Mahanuddy at Naraj (the point of departure of the Katjooree (or the common head, as it were, of the two arms treated as independent rivers) was found to be 12 feet superior to that of the Katjooree, or 8 feet superior to the Mahanuddy, at the points at which they were respectively gauged. From this it appeared, that the fall of the cold weather stream of the Katjooree was $\left(\frac{12 \text{ feet}}{6 \text{ miles distance between the gauges}=}\right)$ 2 ft. p. mile, and that the fall of the cold weather stream of the Mahanuddy $\left(\frac{8 \text{ feet}}{9 \text{ miles distance between the gauges}=}\right)$ $\frac{8}{9}$ ft. p. mile; that the one river had in fact more than double the fall of the other in its dry weather water line. Now looking to the routes to the sea of the two rivers, being of very similar lengths (a fact calculated to produce similarity of regimen), I first argued that some disarrangement or other in the regimen of one or both rivers must have been effected. The head of the Katjooree was believed to have been unduly enlarging of late

years, and I thought therefore that the chief disarrangement would more probably be found in that river than in the Mahanuddy. I next conceived that such disarrangement of the one river would necessarily produce disarrangement in the other; and that the disarrangement would probably have taken place in both, though to a greater degree in all probability in the Katjooree than in the Mahanuddy river. Viewing the circumstances of slope in the 2 rivers in another light, however, it seemed to me that the fall at the head or uppermost portion of the Katjooree (2 feet per mile) might possibly be the natural one in that portion; inasmuch as it would admit of decrease of fall obtaining in successive portions of the river lower down, till the sea were reached by the species of section found to obtain in Delta rivers, (viz. one in which the slope decreased gradually from the head of the Delta towards the ocean): and on the other hand it seemed that the slope at the head of the Mahanuddy (of less than 1 foot per mile) was one which would have to be maintained continuously in order that the water line should terminate at the sea; and would therefore be an unusual slope to obtain at the Delta head; an unnatural one altogether. On this second view, the disarrangement of the Mahanuddy by being silted up, appeared a safe conclusion; but it did not seem necessary that the Katjooree should have deepened out, saving inasmuch as deepening of the Katjooree might follow as a necessary consequence the silting up of the Mahanuddy river. Thus two distinct views presented themselves to me after the consideration of the fact brought to notice by the gauge observation of the 24th June, 1855. Both presented grounds for a conclusion as to derangement having taken place, but the one inclined me to a belief that the deepening of the Katjooree was the great change which had been effected, whilst the second and more careful view, convinced me that whether or not deepening had taken place in the Katjooree, a silting up of the Mahanuddy, near its head, had indubitably occurred. I therefore adopted the assumption that the bed of the Mahanuddy had silted up, and that most probably a deepening had been in operation in the Katjooree river.

22. As nothing more could be gleaned from observation No. 1, let me now move on to the consideration of the next fact presented to notice by the Diagram, viz. that "on the 3rd July, the levels of the two rivers were identical; standing the while 9½ and 5½ feet above the dry weather levels of the respective rivers." To what conclusions did this

fact lead me in connection with the assumption drawn? In the absence of any gauge observation, made simultaneously at Naraj, I had no further light thrown by this fact No. 2, upon the precise slope which might attend a state of perfect regimen in the pair of rivers; but one very important conclusion I was enabled to draw, viz. that their disarrangement from that state of perfect regimen must have been on a very large scale indeed, as I will now explain. Whatever might have been the regimen slope of the pair of rivers (such slope being somewhere between the limits of 2 feet and 1 foot per mile, which I set in the last para.) from which regimen slope the dry weather levels might have varied, (as evinced by gauge measurements of the rivers) when containing a paucity of water in their channels; such regimen would have been returned to by the rivers, on their channels being filled, even by a very small flood indeed, under any circumstances saving those of a silting up of one of them to such extent that free communication could not take place. According as the regimen slope of the rivers might have been 2, 1½ or 1 foot per mile, so would the level of the Katjooree at the gauging point at Cuttack have been (9 miles — 6 miles =) 3 times 2, 1½ or 1, (i. e. 6. 4½ or 3 feet) higher than the Mahanuddy at the point at which it had been gauged. When the two rivers containing floods sufficient to raise the one 9½ and the other 5½ feet above its dry weather level, were found to have, instead of this difference, an identity of level, at points respectively 6 and 9 miles from their points of separation; when in fact the lines of the two rivers' floods crossed each other high up in the Diagram, it became manifest to me that the silting of the latter river here alluded to, must have proceeded to very great lengths indeed.

23. Accepting this assumption of alarming silting of the Mahanuddy (drawn on fact No. 2,) let me pass on to note the next fact presented to notice by the Diagram (fact No. 3,) viz.; that "on the 9th, 16th and 29th July, culminated certain floods of 16, 23½, and 32 feet above the Katjooree dry weather level; floods of various levels each higher than its predecessor; and that the differences of level in the two rivers were severally 3½, 5, and 6 feet on the occasions named." From this set of facts most important deductions were drawn, 1st. During a state of a maximum flood, such as prevailed on the 29th July, the communication of both rivers must necessarily have been the very freest possible, and, under the circumstances, it was impossible that the regimen slope of the flood should be greater than

$$\left(\frac{\frac{6}{3}\text{ feet difference in level between the two rivers}}{\text{Difference between the distances in miles between the 2 points}}\right)=2\text{ feet}$$

per mile. 2nd, the regimen slope in low floods being necessarily less than that in larger ones, owing to the fall to the sea being less in the lower flood; I was enabled, referring back to a previously established fact (No. 1), not only to increase my faith in the soundness of the deductions which I had drawn from it, but to carry deduction further; inasmuch as knowing, with fact No. 3 before me, what fact No. 2 failed to inform me upon, viz. that the regimen slope of the Katjooree, in all states but one of highest flood, was necessarily less than 2 feet per mile, I could in consequence draw a conclusion as to the deepening of the Katjooree, previously not warranted.

24. I shall now pass on to the consideration of the next fact (No. 4,) presented to notice by the Diagram, viz.; that "on the subsi- "dence of the flood, the two rivers stood on the 10th August, at a common "level, one foot higher than that at which they had stood together on "the 2nd July." Now from this fact the important deduction was drawn, that during the high flood of July the disarrangement of the two rivers was materially increased, as evidenced by the lines in the diagram expressive of the comparative rises and falls of the two rivers, crossing at a higher level than they did before the flood.

25. Again, the consideration of another fact (No. 5,) viz. "of the "lines in diagram crossing again at this last common level, on the 21st "August, when another flood was rising; and of their crossing for the "third time on the 30th September, precisely at this common level, when "the flood was falling;" not only established fully the correctness of the conclusions which I had drawn from fact No. 4, but offered a most satisfactory proof, that gauge measurement of rivers entirely disarranged in their levels, and under very complicated circumstances; might be as implicitly relied on as certain indicators of the circumstances obtaining in them, as they could be in the case of the most regular channels.

26. Lastly I will notice a fact (No. 6,) presented for consideration by the diagram, viz. that "in between the 20th and 30th October a "small flood raised one river 1½ feet, and the other 3½ feet," which, being impossible under circumstances of free communication between the rivers, confirmed the correctness of the conclusions come to previously.

27. Thus I have shown my reader (at least I trust so) that the consideration of one simple diagram costing the Government only the

few rupees which I had occasion to expend in preparing and setting up a wooden gauge, enabled me *at once* to predict, with what appeared to me perfect certainty, and has since been proved to be perfect accuracy, all I now care to have learnt of the disarrangement of the levels of the Mahanuddy and Katjooree rivers, from costly surveying operations occupying several years: I need say nothing further in order that the value of gauge measurements of rivers, may be as fully appreciated as they deserved to be; so I will bring these somewhat lengthy remarks on the subject to an end, and pass on to the consideration of the

PRINCIPLES ON WHICH THE NARAJ SPUR WAS ORIGINALLY PROPOSED FOR CONSTRUCTION.

28. The principles were simply these: 1st that "by placing it judiciously, in a position favorable to its own stability, it should have the opportunity of acting as it was intended to do." 2nd, that "the action should be such as, by annihilating the draught down the *Katjooree*, in the dry season, obstructing it very materially in low floods, and to a limited extent in high ones; would produce in the *Mahanuddy* a draught corresponding at all times to that existing in the Katjooree: an action in fact which would lead to the then present conditions of the two arms of the parent river being completely reversed."

29. Were I to write any number of pages on the subject, I do not think I could set forth a whit more clearly than I have done in the last paragraph, the principles on which this "tentative* process" rests. In the matter of what its adoption was to lead to, there could be no difficulty in determining. Whatever *was* in the *Katjooree* had *to be brought to pass* in the *Mahanuddy* and vice versâ. In the dry season all the water of the parent stream found its way into the Katjooree;† none into the Mahanuddy. The spur would at once force the whole into the Mahanuddy and allow none to enter the Katjooree. In low floods the communication of the parent river with the Katjooree, was free as could be; and that with Mahanuddy arm considerably obstructed. The spur would at once decrease and increase respectively, the degrees of

* The process has been aptly termed by Colonel Baird Smith the "tentative process," in the valuable and encouraging letters which I have received from time to time from him on the subject of the Naraj Spur. To the officer named I am indebted for the suggestion of a front and rear apron to my work, and I take the present opportunity of acknowledging obligation to him in this and other less important respects.

† Though this was not actually the case in 1855, it was so in 1857, when the bed of the Mahanuddy was completely dry at Kukkur, (which place see in Plate III.)

freedom of communication, in such manner as to completely reverse the conditions. In high floods the draught was somewhat excessive in the Katjooree. The spur would at once cause the excess of draught to obtain in the Mahanuddy. The volume of the water discharged by the Katjooree had in the course of some years become greater in proportion to the capacity of its branches, than was the volume discharged by Mahanuddy compared with the capacity of its branches. The spur would in the course of some few years reverse these conditions too—why should it not?

30. Generally speaking; circumstances productive of excessive volume in the head of Katjooree had caused disarrangement. Generally therefore any work which would throw an excess into the Mahanuddy was the work required. The spur was wanted—acting upon the current of the main stream, which was found shortly after entering the gorge between the Dawakote and Sydessur Hills (vide Plate III.) to split into divisions taking directions indicated by the "lightly dotted" arrows, the spur could stave off the division for awhile; and by giving to the divided lines of current directions such as the arrows "darkly dotted" in Pl. III., could add to the volume entering the head of the Mahanuddy arm and diminish that received by the Katjooree. It could not only do this by decreasing the length of the path of the current in the Mahanuddy and increasing the same in the Katjooree; but also, while leaving the current of the former its very fullest play, by placing itself as an obstacle, to break up and scatter the force of the latter, and to impede considerably, though not to arrest, the latter's start for the Bay of Bengal from the point of its departure from the parent Mahanuddy.

31. Or, again referring to gauge observations, whatever *was observed* on the Katjooree gauge had *to be produced* as much as possible on the Mahanuddy gauge and vice versâ. The dry season level of the Katjooree was low, and that of the Mahanuddy high. The spur was to produce a heightening of the water level on the former gauge, and a lowering of the same on the latter.—The lines in the diagram Pl. VI. expressive of the comparative daily rises and falls of the two rivers, were found to intersect one another in a far from low flood state. The spur was called upon, at first to bring down the level at which these lines were found to intersect as low as possible; and in course of time to prevent their intersection taking place at all, saving as an effect of certain new

conditions imposed by it (the spur) the bearings of which will be explained hereafter in a more suitable place.

I will now briefly notice the

PROGRESS MADE IN THE CONSTRUCTION OF THE NARAJ SPUR UP TO THE END OF THE YEAR 1859.

32. Having in Plates I. and II. shown by longitudinal and transverse sections, the dimensions given to all the various portions of the work; having marked on these sections lines dividing them into portions, and having lettered such portions so as to make them expressive of the periods during which they have severally been constructed; having in fact made these sections tell, as far as possible, the tale of the work's construction, there is but little left for me to say; a few general remarks however may perhaps be capable of being made on this subject.

33. The Naraj Spur was originally commenced in 1856. As soon, however, as a few thousand feet of rough stone had been collected and placed in the position indicated (by the black shade) in Plate I., work was ordered to be suspended, and it was not until June 1858, that it can be said to have been practically put in hand. Ere the floods of the year last named rendered a temporary cessation necessary, a length of 750 running feet had been projected from the right bank of the Katjooree; and between the subsidence of said floods and the end of the year 1858, a further length of 675 running feet was run in; making the aggregate work of the year the construction of 1425 running feet of spur, raised to the irregular section shown in Plate I. In 1859 the spur was, before the floods set in, carried across from the termination of the work of 1858 to the opposite bank of the Katjooree; giving a total length to the work of 3,000 running feet. The portion of the work executed before the floods of the year 1859, may be seen from Pl. I. to have been raised only just above the cold weather water level of the river, and Plate II. the outlines of the figures in which, indicate the sections to which the breadth of the work has been increased, up to the end of the month of November 1859; also shows, by lines marked on the figures which it contains, the sections to which the work had advanced at various points at the time of the floods of 1859 setting in.

Two small pieces of rear apron aggregating a length of 860 running feet were also placed in position before the flood of 1859; they were run out to a distance of 100 feet from the centre line of the spur, and were

made 4 feet thick. Their positions are not indicated in Plate I. but they are shown in Figs. 12 to 19 of Plate II. After the floods of 1859 the strengthening of the work done previously, was set on foot and the heightening of it proceeded so vigorously that by the middle of November the spur was carried right across the river, to a level above that of the water in the latter, and thus a head of 2 feet of water was produced above the spur as shown in the Figs. of Plate II. Up to the end of the year 1859, the spur attained the height indicated in Plate I.

34. The amount of the work done and cost thereof I tabulate below.

Year.	Cubic feet of rough stone placed in the spur.	Expenditure.	Remarks.
1856.	60,000	435 6 9	A deduction of 10 per cent. has always been made from the "boat measurement" of the stone and the reduced amount been reported. The cubical content "measured in the work" would give much more stone than the amount shown here.
1858.	3,75,780	8,846 14 10	
1859.	11,53,156	19,026 6 1	
Total.	15,88,936	28,308 11 8	Average rate per 100 cubic feet, ... R. A. P. 1 12 6

In the above table has not been included the cost of tools, powder, &c. &c., supplied from the Ordnance Department, which would add to the rate; but on the other hand it includes the whole cost of tools supplied by this Department, a portion of which may be eventually transferred to other accounts; so that the rate* at which work has been executed may be taken at that given in the table.

This low rate obtaining has materially influenced the

Work prospected for 1860.

35. I must preface this subject by a few remarks upon the past

* That the portion of the work done has been executed at so small a cost has been owing to the untiring energy and excellent arrangement in all matters displayed by my invaluable assistant Mr. Supervisor J. McMillan. Few Europeans would have been able to show, as Mr. McMillan has on one occasion last month, a muster roll of 1001 natives of this province or to work them to their own satisfaction and to that of his own superiors. On the Naraj works men come when they like and go when they like. It is not even proclaimed by beat of "tom tom" or otherwise, that they are wanted at Naraj. The strongest and best men receive but their two annas per diem. No failure of the harvest drives the people to the work, for the past season has been a most favorable one. So the facility found in obtaining labour can be the result only of one simple fact to which I need not point.

Para. 900 "Assigning to the former the section, which on a late tour of inspection the superintendent of embankments recommended for adoption, or dimensions of

Breadth of Lip, ... 20 feet
Front Slope, ... 5 to 1 „
Rear Slope, ... 3 to 1 „

"And the average height being 13 feet and the "average length being 4,900 feet the cubical content "of the work may be taken at 3,950,000 cubic feet "and the cost Rs. 98,750, at a rate of Rs. 2-8 per "100 cubic feet, at which I have little doubt the "work could be substantially executed."

history of the spur. It will be seen from the marginal extracts para. 90 taken from my Report Part I. Cuttack Rivers, that the dimensions originally assigned to the work were as follows.

Breadth of Lip... 20 feet
Front Slope,... 5 to 1 „
Rear Slope, ... 3 to 1 „

Giving as the estimated cost 39,50,000 at 2-8 per 100 cubic feet—98,750 Rupees, but that the dimensions which I personally thought necessary were much less, vide marginal extract para. 91, viz.;

Para. 91, "I should have every confidence in "reducing the dimensions named above and giving "front and rear slopes of 2 to 1 to, and 1 to 1 respectively, in which data the cubical content of "the work becomes reduced to 25,16,000 cubic feet, "the cost to Rupees 62,900."

Breadth of Lip, ... 20
Front Slope,..... 2 to 1
Rear Slope, ... 1 to 1

Giving as the estimated cost 25,16,000 at 2-8 per 100 cubic feet Rs. 62,900.

36. Neither of these plans or estimates was in the first instance sanctioned; but at the recommendation of Colonel Arthur Cotton, a sum of Rupees 20,000 was placed at my disposal in May 1858, to commence a work or works of some kind or other calculated to improve the conditions of the two arms of the Mahanuddy. In January 1859 a further grant of Rupees 30,000 being promised, a revised estimate was submitted to Government, for a work which should cost 50,000 or thereabouts. The opportunity was taken of introducing into the design front and rear "aprons."*

37. The general dimensions of the revised project were designed as follows with particular reference to the limit of expense assigned.

Breadth of Lip,..... 4 feet
Front Slope,..... 1 to 1 „
Rear Slope, ... 1 to 1 „

Breadth of front apron equal to the height of spur.
Ditto Rear ditto 4 times ditto ditto,
Thickness of both aprons 4 feet.

* Suggested to me by Colonel Baird Smith as mentioned in note to para. 28.

The cubical content of the work proposed was as follows :—

Body of work,.....	9,60,000
Front apron, ...	2,40,000
Rear apron,.....	8,16,000
Total,.....	20,16,000

Substituting 2-4 per 100 cubic feet, as my rate, in lieu of 2-8 as in first estimate. I obtained the estimated cost 20,16,000 at 2-4 per 100 cubic feet 49,680 rupees.

38. In order to reduce the estimate to the sum shown above, it was necessary in designing the work, to make it taper off from the right bank, to no higher than the water level on the opposite one; in lieu of being carried across at a dead level from one side of the river to the other, as it was originally intended to have been.

39. The above being the history of the spur, the prospects of the work in 1860 become bounded by the amount of (Rupees 50,000—Rupees 28,000=) Rupees 22,000, the balance which I have in hand for expenditure during the year: and setting aside the 17 or 18,000 which must be spent on the front and rear aprons the height to which I can raise the work is limited to that which an amount of 4 or 5,000 Rupees will defray the expenses of. Under these circumstances the work I prospect for the current year is "the construction of the aprons" (front and rear) and "the raising of the body of the spur," as nearly as possible to the level (or rather set of levels for the work is designed in steps) shown in Plate I. as the "section for completion before the flood of 1860."

40. It is satisfactory to be able to state in this place, that I have every hope of being able not only to complete the work to the section now proposed, with the funds placed at my disposal for the purpose, but well within the time by which it would be desirable to have it done; viz. before the flood season of this year sets in. In this hope I will close this branch of the subject under report, and proceed to show the

Results of the incomplete work observed in 1859.

41. In my letter No. A. of the 7th January, 1859, I have already reported as an effect of the "brushwood operations" on the Katjooree, a considerable silting up of the bed of that river; it is necessary to make

allusion to this statement here, lest the Naraj spur might be supposed to have accomplished more than it has really done; which I should be as sorry for as that what it has accomplished should fail to be fully recognised.

42. The measure of the improvement effected by the "brushwood operations" may be readily taken from Plate VII. When the river's bed was generally deep as in 1855, vide Pl. VI. the dry weather level fell as low as 94.92 above my survey datum; and after the bed had been raised by the "brushwood operations," or up to the time of the spur at Naraj being put into condition to work at all, (i. e. just prior to the rains of 1859,) the dry weather level of the Katjooree had been raised to 97.80. No other conclusion can be drawn from the comparison of these two levels, save that the Katjooree bed had silted up (97.80—94.92=nearly) 3 feet in between the floods of 1855 and 1859. This was due to brushwood operations, not to the "spur." To the "brushwood operations" was due, the improvement whence it results that the lines expressive of the "daily rises and falls" in the Mahanuddy and Katjooree intersected each other at a low level on the 1st June, 1859, (vide Pl. VII.) in the way I said in para. 31, that they should do in the first stage of improvement. To the "brushwood operations" is due in a great measure the parallelism of movement of the lines of the two rivers which in Plate VII. is so striking as compared with the want of parallelism in Plate VI.

43. Whatever changes may be found to have been effected in the Mahanuddy and Katjooree rivers since the setting in of the rains of 1859, the "spur" shall have due credit for effecting, providing they be such as it is manifestly calculated to bring about, and such as are not likely to have been effected by any other change-producing agent.

44. Before going into the results of the "spur," I will anticipate and explain the cause of one of those seeming paradoxes which, I have said, arise in the gauge measurements of rivers, and which will break upon the reader sooner or later certainly, and perhaps at first sight of the diagram of the floods of 1859 (Plate VII.).

In para. 31 of this report I have said that the "spur" was called upon to "bring down the level at which these lines (those expressive of "the daily rise and fall of the two rivers) intersect, as low as possible "and in course of time to prevent their intersection taking place at all "*except as an effect of certain new conditions imposed by it* (the spur) the

" bearings of which will be explained hereafter in a more suitable place." It would seem that the suitable place is now reached, for I have at this point to draw the attention of my reader to the fact of a change of circumstance having been introduced, in the beginning of the month of October 1859; owing to which change, the movements of the two rivers as indicated by the diagram must, unless care be used, be judged of by an entirely new standard of comparison. I allude to the fact that during the period intervening between the 1st day of October, and the middle of November, 1859, the spur at Naraj was heightened to an extent which raised the water about the weir supplying the Mahanuddy, 2 feet and more higher than that below the spur supplying the Katjooree. Up to the 1st October, 1859, the level of the source of supply to both arms, had been identical; the gauge measurements therefore up to that date may be readily and profitably compared with those taken in 1855, or in intervening years; but on the other hand the measurements after 1st October can be compared with neither those taken before that date in the same year, nor the measurements taken in any previous years; unless indeed allowance be carefully made for the effect due to the alteration of circumstances noted above. The seeming paradox which I am about to anticipate is this: A hurried and wrong conclusion might be come to, that as the lines in diagram (Plate VII.) expressive of the rises and falls in the two rivers during the middle of November, intersect at a higher level than they had done at the beginning of June; an unfavorable change must have taken place: whereas it will be seen on a careful consideration of the alteration of circumstances, that an allowance for the difference of head of water in the rivers (2 feet or so) must be made in this portion of the diagram, prior to any comparison being made between the indications offered by it and those presented by the other portion. It may make my meaning clearer possibly, to suppose a case, though an impossible one, in which the comparison of all the parts of the diagram might be made without any allowance for alteration of circumstances; viz. that of " the temporary removal of the spur." In such case the head of 2 feet would be removed in the course of a few hours, the result being the upraising of the Katjooree level, and the lowering of that of the Mahanuddy, so that the lines in diagram instead of intersecting at all, would remain completely separate. Thus it will be seen that the paradox which I anticipated, is but a seeming and perfectly intelligible one; and that though the diagram of 1855 is not one

calculated to remain, what it has hitherto been, a very easy standard of comparison, yet that it is still a standard to which reference may be made henceforth, if due care be taken, to allow for the effect of the head of water acting above the spur. As after the clearance of the Mahanuddy may have been effected, I contemplate the lowering of a portion of the spur, in such manner that no head of water shall exist in the dry season (in which case the diagram of 1855, will revert to its position of an easy indicator) I think, it would be unwise to substitute any other for it as a temporary measure.

45. I will now make use of it, to the extent to which I have said it may be used without allowance of any kind on account of altered circumstances, viz.; to compare with it, the movements of the Mahanuddy and Katjooree, during floods of 1859, prior to October; or rather I should say, I will compare the relations of the surface levels of the two rivers, which obtained during 1859, prior to the month of October, with the relations which obtained at corresponding levels in 1855.* The former are shown in Plate VI., only at the levels, at which the floods of the two rivers happened to be, at the same hour once per diem; but during the flood season of 1855, hourly measurements were taken, and a mass of observations was made from which I compiled tables 16 and 17 Report, Part II., showing the precise relations between the two rivers at all variations of level; and it is to one of these (Table 17,) that I shall refer here, as it gives in a more detailed form, the information which is conveyed in Plate VI. in a general form only.

Dates of maximum floods during the year A. D. 1859.	Guage measurements reduced to ⊖ of Lall Bagh Guage.						
	Katjooree.			Mahanuddy.			
	Made at Belle Vu.	Subtract to reduce to measurement at Lall Bagh.	Lall Bagh.	Subtract to give corresponding height of Mahanuddy in 1855.	Height due to Mahanuddy in 1855.	Height measured in 1859.	Difference of columns 6 & 7 or extra height of water in the Mahanuddy in 1859.
1	2	3	4	5	6	7	8
25th June, ...	19.25	.70	18.55	5.07	13.48	14.56	1.08
29th July, ...	18.72	.69	18.03	5.09	12.94	14.10	1.16
6th September,.....	20.18	.72	19.46	5.12	14.34	14.99	.65

* To this end, Table III. of Appendix should be consulted.

From this Table, (vide copy, Table 3 in Appendix,) I have made the calculations given in the Table subjoined; to the 8th column of which I would now draw attention. It appears from this table, that during the 3 large floods of 1859, the surface level of the Mahanuddy, (at the point at which it has always been gauged at Cuttack,) was raised by some cause or other the subjoined heights above the levels, which corresponded in the Mahanuddy in 1855, to the heights obtaining this year in the Katjooree river, during these 3 high floods, viz.:

In 1st flood 1.08 feet or 13 inches.
In 2nd ditto 1.16 feet or 14 inches.
In 3rd ditto .65 feet or 8 inches.

Nothing could have effected this increased level, but excessive volume being *forced* into the river, and nothing but the spur could have forced that extra volume in. I italicise the word "forced," to give the fullest expression possible to what I believe to have been the case, viz.; that the levels of the 2 first floods were unnatural ones; levels which could not be maintained; because, though the necessary consequences of extra volume on its first production by an extraneous cause, they were consequences which could not continue for a lengthened period, inasmuch as such extra volume will and does find a return path to its natural level by deepening or widening the channel, or escaping in some way or another. That the last and largest flood of the season (vide Plate VII.) should have produced the least extra level at Cuttack, I can account for by finding, since the dry season has set in, that both the bed and water lines of the Mahanuddy have fallen 18 inches (vide Plate VIII.) In my report of the fact of the last flood having only caused 8 inches rise, whereas previous floods had caused respectively 13 and 14 inches, I expressly predicted such change being found to have taken place; and it is now certain that the change has been found. That such change could be effected by extra volume forced into the Mahanuddy, there can be no doubt; but it may be necessary that I should show how it could be forced in by the "spur," so I will say a few words on this point in addition to what I have written in paras. 28 to 31. Referring to Plate IV. I would observe, for though the fact be pretty generally known, I was ignorant* of it myself until I had noticed its operation in the Maha-

* My ignorance must plead my excuse for having in my Report, Part I. noticed this fact as a discovery, rather than as the generally known fact, which I have since learnt it to be. I wrote as follows in the Report alluded to.

nuddy, that the upper surface of the transverse section of a river is a warped (not a level) line, having its highest level in the path of the current; and that consequently, where the common feeder of two rivers, such as the Mahanuddy and Katjooree, is a river of the section shown in Plate IV., it makes a vast difference whether the path of the current be at A. or B.; and again whether the right or left half of the section be the broader and deeper one—now, as the spur was observed during the past floods to throw the path of current towards B.; and as the left half section of the river, feeding the arm retaining the parent name, has deepened considerably during the past year; an effect likely to have been produced by the shifting of the path of the current, I think I may draw the conclusions, both that extra volume was forced into the Mahanuddy during the year 1859, and that the "spur" was the cause.

I will turn now to the

Results projected of the Spur.

46. This subject suggests a division into two natural headings.

1st. The result of the spur's action upon the rivers.

2nd. That of the river's action on the spur.

The former result may be prospected with considerable readiness and accuracy, inasmuch as it is not dependent to any very great extent upon the character of the floods which may prevail during the coming rainy season. The "spur" has been designed expressly to accommodate its action upon the river to all states of flood. In the low flood it will force a large proportion of the river's volume down the Mahanuddy arm, without affecting the Katjooree, except so as to diminish slightly its volume. In the medium flood the "spur" will still force a large,

Para. 53: "The next effect of the action of rivers which I have to notice, not as a "phenomenon, but an easily explained fact and one most important of consideration in "Engineering matters, is that the upper surface of the transverse section of a flood is not a "horizontal line but (a curve, or for purposes of argument say,) a triangle, the apex of "which is variously situated in such transverse sections according to the position in them "of the point of maximum surface velocity. These points of maximum velocity and level "form a connected line, following generally the path of greatest depth, called by German "Engineers the 'thal wag'* of a river. In a straight run of river where this path lies in "mid-channel, the upper surface of the transverse section of the flood will consist of two "equal inclines from centre of stream to bank on either side. This is owing to excessive "velocity in the topmost particles and to the centrifugal force in a vertical plane which "they acquire from their position. Now if a river's course be winding, the path of greatest "depth will cross and re-cross the stream, and so also the lines of maximum velocity and "level; and the position of the apex of transverse section of the flood will be such, that its "upper surface will consist of two inclines of different lengths of base, between the line of "maximum local levels and the banks."

* "Thal" a valley—"wag" a road.

though not so large, a proportion, down the first named arm, to effect clearance of its bed as before; and whilst diminishing the volume and moderating the velocity of the water passing down the Katjooree arm, it will prevent that river deepening its bed near Cuttack and cause a mild silting* action to set in at that place; and a more vigorous one near the head of the river. Lastly in high floods the "spur" will produce, both excessive volume and velocity in the Mahanuddy, calculated to deepen its bed on a large scale, and to produce a correspondingly diminished volume and velocity in the other river, favorable to the safety of the town of Cuttack and the Pooree district. As probabilities are in favour of floods of all the above characteristics occurring in the coming season, I may safely prospect all the above mentioned degrees of change being evinced, and a large aggregate of improvement being effected in the deepening out of the Mahanuddy bed. During the flood season the indications given by the gauges will be puzzling possibly, but unintelligible to myself and inexplicable to others they can never be. At the close of the season, all perplexity will necessarily be at an end, for one simple observation of the surface level of the Mahanuddy gauging point, will suffice to indicate the change effected. If that level prove lower than it is this year, the bed of the Mahanuddy will have been proved incontestibly to have deepened; and if the reverse indication be given by gauge measurement, the Naraj spur will stand condemned, a failure of the highest order.

47. Though it will be satisfactory to have sections of the Mahanuddy taken year by year, in order to trace continuously, step by step, the changes which the spur may be effecting, both in point of deepening and widening the now obstructed channel of that river, (gauge measurement is merely the index of the former effect) yet the test given above, is the only one essentially necessary to a knowledge of what may be or have been going on. As an essentially necessary, simple, and infallible test, I would recommend that it should be applied annually on a stated day, henceforth, until a perfectly satisfactory arrangement of the relative conditions of the two rivers be brought about; and thenceforward also, that subsequent derangement may never again set in, without being noticed. By the 1st day of January the level of the

* The brushwood operations have already raised the bed of the Katjooree 3 feet at Cuttack; very little more silting up is needed there, but the head of the river may yet with advantage be silted up considerably.

rivers is sufficiently low under ordinary circumstances, for the* test to be satisfactorily applied; and when in any particular season, owing to lateness of the floods or other cause, an unusual amount of volume might be found in the rivers (as evidenced by high level on the gauges of both rivers) a second measurement should be made later in the year.

48. The result of the "river's action of the spur," I cannot predict with anything like precision, as this depends so much upon the character of the floods, to the action of which the work may be fated to be exposed this year. The low flood will deposit sand between the spur and the point A. (Plate III. Fig. 2,) and thus add to the stability of the work. It will cut away and enlarge the head of the Mahanuddy at C. thereby relieving the pressure on the spur. On the other hand, it will pour through the interstices between the rough stone work of the "spur," with a velocity proportional to its afflux, and will induce in the tail of the work (vide 3 last spaces of 300 feet shown in Plate I.) which is of little depth below the cold weather level, a tendency to settlement. A medium flood will have a tendency to deposit sand where the low flood was represented to induce settlement, but it will also itself evoke that same tendency to undermine the work, not only along the weak portion of the line noticed, but all along the last 600 feet of the tail of the spur which is not shown in Plate III. (vide note at foot of Pl.) Lastly a large flood will, without a doubt, add to the length of the sand-bank between points A. and D., and help to close the head of the Katjooree river. It will also heap† up sand at D. and E. near the tail of the "spur," and again beyond the end of the work; but unless it subside rapidly, it would, in its lower stage, cut away again the deposit beyond the end of the "spur," which it had caused when at its maximum level. A large flood on the other hand would necessarily deepen the bed of the river, above and below the site of the "spur," and mar

* A masonry gauge will be erected this year in the bed of the Mahanuddy river. Hitherto a temporary wooden gauge has been used, at the risk of its being carried away at any moment. But for the want of a fixed masonry gauge I should have been able to have recorded the movements of the Mahanuddy, during the years intervening between 1855 and 1859, in the same complete manner as I have been able to record those of the Katjooree.

† I doubt much this effect being credited, but in the course of a few years, I trust will have been realised in practise, what theory points to as the necessary effect, viz.; the burial of the tail of the spur in a mound of sand.

The end of the spur may settle in one year, it may further settle again in a second year, but once let it find firm footing, and the first large and rapidly subsiding flood will bury its tail completely, I feel certain.

much the conditions of stability produced by the silting action of the minor floods.

49. The above would be, I imagine, the general effect produced by the action (during a limited period) of each individual kind of flood. Could I presage the varied characteristics of those floods, to which the "spur" is fated to be exposed during the coming year; were I to foreknow the level, velocity, volume and duration, which will obtain in each and the amount of sedimentary matter, the Mahanuddy may be destined to bring down during the current year; I could not do more than conjecture indefinitely the eventual result. I will not in this place therefore hazard a conjecture even; but will conclude this paper simply with a hope that when the flood season of 1860 shall have passed away, the dry weather volume of the Mahanuddy river, may be found to pass Naraj and Cuttack in one continuous stream;* shut off from the Katjooree, not only by an uninjured "spur," but by a bar of sand thrown up with its assistance by the floods.

JOHN HARRIS, CAPTAIN,
Ex-Engineer, Mahanuddy Division, D. P. W.

* A small gap will be left in the spur in order not to interfere unnecessarily with the traffic on the Katjooree, sections of the "gap" proposed are given in Pl. V.; which being drawn with horizontal and vertical measurements on the same scale, will convey a better idea of the thickness of the "spur," to persons unhabituated to drawings on the distorted scale which has been necessarily resorted to in the other drawings, than that which may be conveyed by them.

APPENDIX

TO

REPORT ON THE NARAJ SPUR.

No. 1.

Table of the Transverse Sections of the Naraj Spur, taken at every 100 *feet in its length, during the month of November,* 1859, *showing the "deepening" or "silting" of the river-bed; immediately above and below the work, caused by the action of the floods of* 1859.

Naraj, 20th January, 1860.

No. of Section.	Distance from B. M. tree on right bank of River at Naraj.	Reduced Levels of deepest points in			Silting or deepening above and below the spur.				Remarks.
		Base of spur.	Bed of River above below spur.		Above.		Below.		
					Deepg.	Siltg.	Deepg.	Siltg.	
		Feet and Decimals.			Feet and Decimals.				
1	100	116.50	108.13	114.84	8.37	...	1.66		The figures in columns 4 & 5, indicate the "reduced levels" (referred to the Cuttack River Survey "datum") of the lowest points in the transverse sections of Plate II.
2	200	112.00	107.93	111.44	4.07	...	.56		
3	300	111.75	104.50	103.90	7.25	...	7.85		
4	400	108.24	103.70	104.00	4.54	...	4.24		
5	500	108.50	101.65	102.26	6.85	...	6.24		
6	600	104.00	100.40	100.90	3.60	...	3.10		
7	700	102.00	96.90	95.00	5.10	...	7.00		
8	800	102.00	96.90	97.72	5.10	...	4.28		
9	900	100.00	93.98	96.57	7.02	...	3.43		
10	1,000	98.50	93.00	89.65	4.50	...	8.85		
11	1,100	96.40	91.90	86.06	4.50	...	10.34		
12	1,200	97.15	91.90	91.30	5.25	...	5.85		
13	1,300	96.15	91.40	87.50	4.75	...	8.60		
14	1,400	95.00	92.00	89.40	3.00	...	5.60		
15	1,500	95.00	91.90	88.60	3.10	...	7.40		
16	1,600	95.40	92.00	89.90	3.40	...	2.10		
17	1,700	95.60	93.90	93.40	1.70	...	2 20		
18	1,800	94.60	94.40	93.30	.20	...	1.10		
19	1,900	91.25	94.50	93.25	...	3.25	...	2.00	
20	2,000	92.50	95.90	93.70	...	3.40	...	1.20	
21	2,100	90.50	97.40	94.60	...	6.90	...	4.10	
22	2,200	92.60	98.90	94.90	...	6.30	...	2.30	
23	2,300	93.00	100.30	92.80	...	7.30	...	.20	
24	2,400	95.25	101.90	91.70	...	6.65	3.55		
25	2,500	96.60	103.30	98.30	...	6.70	...	1.70	
26	2,600	96.00	104.90	99.70	...	8.90	...	3.70	
27	2,700	100.00	106.60	105.50	...	6.60	...	5.50	
28	2,800	101.75	107.20	105.90	...	5.45	...	4.15	
29	2,900	107.64	107.90	105.60	...	.26	2.04		
30	3,000	108.75	108.60	107.30	.15	...	1.45		
31	3,100	108.24	109.30	108.40	...	1.06	...	.16	
32	3,200	108.44	110.10	108.70	...	1.66	...	.26	

Sections Continued.

No. of Section.	Distance from B. M. tree on right bank of River at Naraj.	Reduced Levels of deepest points in			Silting or deepening above and below Spur.				Remarks.
		Base of Spur.	Bed of River above below Spur.		Above.		Below.		
					Deepg.	Siltg.	Deepg.	Siltg.	
		Feet and Decimals.			Feet and Decimals.				
33	3,300	109.34	110.40	108.70	...	1.06	.64		
34	3,400	110.24	111.10	109.30	...	.86	.94		
35	3,500	110.24	111.03	109.32	...	.78	.92		
36	3,600	111.49	112.07	110.30	...	.58	1.19		
37	3,700	112.49	112.25	110.94	.24	...	1.55		
38	3,800	114.34	114.38	112.72	...	.04	1.62		
39	3,900	117.24	116.48	114.48	.76		2.76		
40	4,000	118.23	118.23	118.29	Not known.				
41	4,100	118.80	118.80	118.80					
42	4,200	118.17	118.17	118.17					
43	4,300	118.55	118.55	118.55					
44	4,400	119.29	119.29	119.29					
45	4,500	120.00	120.00	120.00					

JOHN C. HARRIS, Capt.
Ex. Engr. Mahanuddy Div. D. P. W.

No.

Table showing the monthly progress made in the construction of the Naraj Spur, in the work between the 1st June, 1858 and instructions received from

Month in which was executed.	Year.	Cubic ft. of stone placed in Spur monthly.	Monthly expenditure including purchases and sundries.	Average monthly rate per 100 cubic ft. (including) all charges.	Average distance stones were carried by coolie in feet.	Average distance stones were boated in miles.	States of the river in which work was executed.	
							During flood.	After flood.
			Rs. A. P.	Rs. A. P.				
June,	1858.	42,720	929 5 1	2 2 9½	200	1	Partly.	...
July,	,,	78,156	1,427 4 0	1 13 2½	200	1	Yes.	...
August,	,,	16,383	389 8 5	2 6 0	1,500	1½	,,	...
September,	,,	1,500	32 7 0	2 2 8½	1,500	1½	,,	...
October,	,,	84,849	1,531 1 9½	...	...	...	...	...
Add cost of stones collected in Augt. and Sept., 1858, but not placed on the Spur,	...	...	680 5 3	...	...	...	...	...
Total expenditure for October,	,,	...	2,211 7 0½	2 9 8½	1,500	1½	,,	...
November,	,,	92,171	1,925 6 6	2 1 5	1,500	2	,,	Yes.
December,	,,	60,000	1,929 14 5	3 3 5½	2,000	2½	,,	,,
January,	1859.	1,57,500	2,793 1 3	1 12 4½	300	¾	...	,,
February,	,,	1,30,000	2,420 1 3	1 13 9½	300	¾	...	,,
March,	,,	1,00,000	1,819 12 5	1 14 3¼	300	¾	...	,,
April,	,,	1,20,000	2,001 6 9	1 10 8¼	300	¾	...	,,
May,	,,	1,51,500	2,537 5 0	1 10 9½	300	¾	...	...
June,	,,	85,372	1,622 5 0	1 14 5	300	¾	Partly.	...
July,	,,	...	...	...	...	...	...	...
August,	,,	61,473	...	...	...	...	...	...
September,	,,	...	...	...	...	...	...	...
October,	,,	2,01,348	1,402 8 5					
Add cost of stone previously collected, but not placed on the Spur,	,,	...	1,483 11 2					
Total expenditure,	,,	...	2,886 3 7	1 6 11	350	¾	Yes.	...
November,	,,	1,40,576	1,086 10 4					
Add cost of stone previously collected,	,,	...	81 2 6					
Collected during this month, but not placed on the Spur,	,,	...	657 5 5½					
Total expenditure,	,,	...	1,825 2 3½	1 4 9¼	1,000	¾	...	Yes.
December,	,,	66,860	613 14 3					
Add cost of stone previously collected, but not placed on the Spot,	,,	...	335 13 0					
Total expenditure,	,,	...	949 11 3	1 6 9	1,500	¾	...	,,
Total work done,	,,	15,28,936	27,873 4 11	1 13 2	Average rate up to end of			

N. B.—These rates do not include the 6652 lbs. 13 oz. of ordnance powder used, nor the cost of in 1856, viz. Rs. 435-6 9.

JOHN C. HARRIS, Capt.
Ex. Engr. Mahanuddy Div. D. P. W.

2.

showing also the expenditure on and rate per 100 *cubic feet of rough stone placed the* 31*st December,* 1859, *drawn up under the the Executive Engineer.*

Cubic feet of stones collected.	Monthly expenditure on collecting stone.	Average monthly rate per 100 cubic feet of stone collected, including all charges.	Statement of monthly purchases.	Statement of sundries monthly.	Officer in charge of work.	Remarks.
	Rs. A. P.	Rs. A. P.				
...	...	...	215 14 11	3 8 0	Supervisor J. McMillan.	The stones were both loose stones, and procured by blasting.
...	...	...	114 2 6	1 9 3		
20,000	233 5 3	1 2 1	69 0 3	0 10 9		
35,000	447 0 0	1 4 5½	4 1 0	1 10 0		
...	...	...	101 9 11	1 1 0	Asst. Overseer F. Hanlon.	The greater portion of these stones were procured by blasting.
...	...	...	...	...		
...	...	...	...	...		The stones placed in Spur were chiefly picked up wherever they could be got on the surface of the small hill at Moondlee and Oree-low; respectively 3 and 2 miles from site of Spur.
...	...	...	261 3 9	2 7 0	Supervisor J. McMillan.	
...	...	...	135 3 2	3 0 6		
...	...	...	213 14 3	7 7 9	Asst. Overseer F. Hanlon.	The greater portion of the stone, collected and placed in Spur, was dug out of the ground between Naraj and the Sydessur Hill.
...	...	...	47 3 6	8 11 0		
...	...	...	45 2 8	3 9 6		
...	...	...	30 9 0	3 15 3		
...	...	...	72 3 0	3 12 6		
...	...	...	58 11 9	14 6 6		
60,000	436 5 6	0 11 7½	5 12 0	1 2 6		
61,473	546 6 4	0 14 2½	19 0 6	72 12 10	.....	The greater portion of the stone collected in Augt., Sept. and Oct., was dug also from the site mentioned above.
1,26,560	792 10 7	0 10 0¼	36 1 9	57 1 4		
1,51,067	700 13 0	0 7 5	152 0 5	4 7 9	Supervisor J. McMillan.	
9,684	81 2 6	0 13 5	62 8 10	19 1 6	.....	The greater portion of the stone collected in Nov., 1859, was procured by blasting.
10,840	99 15 9	0 14 8½	36 3 3	16 1 6	.....	The greater portion of the stone collected in Dec., 1859, was procured by blasting. The cost of placing the stones collected during Dec., will be charged for in the accounts for Jan., 1860.

year 1859.

the tools received from the arsenal, nor again the amount expended by Assistant Overseer Atkinson,

(Sd.) J. McMILLAN,
Supervisor Mahanuddy Div. D. P. W.

No. 3.

Table of corresponding levels in the Mahanuddy and Katjooree rivers at Cuttack, whereby to calculate the height of water in the former at the house used temporarily as a Circuit house from gauge measurements of the latter river, taken at Lallbaugh house (in the state of the river in 1856, *A. D.).*

Water levels of Katjooree at Lallbaugh referred to Cuttack River Survey Datum.	Difference additive or subtractive.		Corresponding water level of the Mahanuddy at Captain Harris' referred to Cuttack River Survey Datum.	Water level of the Katjooree at Lallbaugh referred to Cuttack River Survey Datum.	Difference additive or subtractive.		Corresponding water level of Mahanuddy at Captain Harris' house.
Feet.	Feet.	Diff.	Feet.	Feet.	Feet.	Diff.	Feet.
95.00	3.98	0	98.98	112.00	4.07	.57	107.93
96.00	3.78	.20	99.78	113.00	4.37	.30	108.63
97.00	3.58	.20	100.58	114.00	4.52	.15	109.48
98.00	3.14	.44	101.14	115.00	4.62	.10	110.38
99.00	2.70	.44	101.70	116.00	4.72	.10	111.28
100.00	2.41	.29	102.41	117.00	4.82	.10	112.18
101.00	1.64	.77	102.64	118.00	5.01	.19	112.99
102.00	1.17	.47	103.17	119.00	5.12	.11	113.88
103.00	0.70	.47	103.70	120.00	5.13	.10	114.87
104.00	0.19	.51	104.19	121.00	5.14	.10	115.86
105.00	0.00	.19	105.00	122.00	5.15	.10	116.85
106.00	0.41	.41	105.59	123.00	5.17	.2	117.83
107.00	1.00	.59	106.00	124.00	5.19	.2	118.81
108.00	1.52	.52	106.48	125.00	5.45	.26	119.55
109.00	2.14	.62	106.86	126.00	5.72	.27	120.28
110.00	2.74	.60	107.26	127.00	6.00	.28	121.00
111.00	3.50	.76	107.50				

Add. (rows 95.00 – 105.00)

Subtract. (rows 106.00 – 111.00)

Subtract. (rows 112.00 – 127.00)

Example :—Given the surface level of water in Katjooree 20.49', on Lall-baugh gauge, required the level of water in the Mahanuddy at the house used temporarily as a Circuit house.

Level of Katjooree referred to datum,			120·49
Subtract from, ...	120.00	5.13	
Ditto, ...	.49	.005	
In all, ...		5.135	5·135
Level of Mahanuddy, ...			115·355

No. 4.

Memorandum of gauge observations, made simultaneously during the floods of 1859, *at the old and new Katjooree gauges; situated respectively at Lallbaugh and Belle-Vue; whence from observation of the height of water on the latter gauge to ascertain the corresponding height on the former.*

Season of observation.	Heights on the gauges referred to Cuttack River Survey Datum.		Difference subtractive.	Remarks.
	New or Belle Vue gauge.	Old or Lallbaugh gauge.		
During the three floods of 1859.	119.00	118.30	.70	Both the gauges have the same °. The difference in the readings is chiefly owing to the one (new) gauge being higher up the river than the other (old), but the former is carefully and the latter but imperfectly graduated, on which account also a difference is found. Since 1857, all observations have been made on the Belle-Vue gauge, so before making comparison of any flood diagrams, of years subsequent to that named, with the diagram of 1855, (Pl. VI.) the levels at Belle-Vue must be reduced to the corresponding levels at Lallbaugh, on the gauge at which place the flood of 1855 was measured.
	117.80	117.12	.68	
	117.50	116.82	.68	
	117.28	116.64	.64	
	117.12	116.39	.73	
	116.68	116.08	.68	
	116.34	115.72	.62	
	116.00	115.40	.60	
	115.67	115.10	.57	
	115.35	114.92	.43	
	115.03	114.59	.44	
	114.68	114.30	.38	
	114.32	114.02	.30	
	114.02	113.72	.30	
	113.75	113.46	.29	
	113.42	113.20	.22	
	113.23	113.03	.20	
	113.02	112.81	.21	
	112.77	112.57	.20	
	112.55	112.36	.19	
	112.30	112.10	.20	
	112.03	111.87	.16	
	111.60	111.52	.08	
	111.43	111.35	.08	
	111.21	111.09	.12	
	111.08	110.96	.12	
	111.02	110.90	.12	

Example:—Given the surface level of a flood reduced to Cuttack River Survey datum—118.72 on the "Belle-Vue" gauge—required the reduced level of same flood on the gauge at "Lallbaugh."

Levels at Belle-Vue, ...	118·72
Subtract (judging from mèmo.).....	·69
Level at Lallbaugh, ...	118·03

No. 2256.

OFFICE MEMORANDUM

Fort William, 23rd August, 1860.

In continuation of his memo. No. 7658, dated 14th April last, the undersigned has the honor to submit, in original, for the information of the Honorable the Lieutenant-Governor of Bengal, the accompanying letter from the Superintending Engineer, Cuttack Circle, No. 119, dated 27th ultimo, with its enclosures, relative to the Naraj Spur.

2. It will be observed that Captain Harris considers the practical utility of the work to have been established in the most complete and satisfactory manner.

C. B. YOUNG, *Lieut.-Col.*
Chief Engineer, Lower Provinces.

No. 3509.

Copy of the above and of the enclosures which accompanied it, forwarded to the Government of India in the Public Works Department for information, with reference to the letter from this Department, No. 1825, dated the 12th May last.

By order, &c.,
C. B. YOUNG, *Lieut-Col.*
Secy. to Govt. of Bengal, D. P. W.

Fort William, the 31*st Augt.*, 1860.

From CAPT. JOHN C. HARRIS, Superintending Engineer, VII. or Cuttack Circle, to Lieut.-Col. C. B. YOUNG, Chief Engineer and Secretary to the Government of Bengal, Fort William, (No. 119, Cuttack, dated the 27th July, 1860.)

SIR,

I HAVE the honor to report that both the stability and practical utility of the Naraj spur have, during the current month, been established in the most complete and satisfactory manner possible.

2. In communicating this gratifying intelligence, I have the honor to forward a sketch map, a table, and a diagram, which, taken in connection one with another, will be found to afford conclusive evidence on both these points.

3. As I propose hereafter to submit a full report upon all the interesting phenomena which have been and are attending, or which may during the remaining portion of the season attend, the practical action of the Mahanuddy and the spur. I will confine myself at present to pointing out a few only of the great facts which have presented themselves and are necessary to establish the two above mentioned points.

4. As respects the stability of the spur, it might suffice to point to its being now in full working order; but I may also notice that danger to the work being proportional to the head of water found to be caused by it, the stability may be considered to have undergone a most ample test, inasmuch as not only has the maximum head (reached on the 20th instant, vide diagram) acted on the work, but the latter has been exposed to various heads, never, during the long period of 17 days, varying from the maximum to as much as $1\frac{1}{2}$ feet.

5. In the matter of the practical utility of the spur I would observe that a work which can produce the heads of water shewn in Column 6 of the table, cannot fail of accomplishing its object of clearing out the Mahanuddy. A reference to the sketch map will make this so clear, that it were useless to make any further remark under this head.

6. I trust the Government may be as well satisfied as I myself am with the success of the spur, which, having exceeded my expectation, is the more likely to have exceeded the anticipations of the Government.

SKETCH MAP
of the Head of the
DELTA of the MAHANUDDY RIVER
showing the position
of the "Gauging points"

SCALE 4 MILES = 1 INCH

Reference.

A.B. &c. *Are gauging points as below*
A. *At Naraje above the* "Spur"
B. " *Cuttack on the City side*
C. " . . . . . *Cantonment.*
D. " *Naraje below the* "Spur"
——— *The* " "Spur"

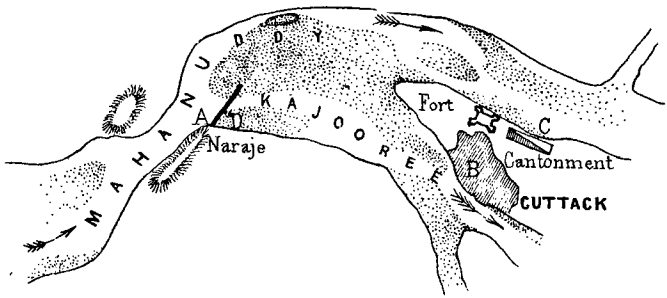


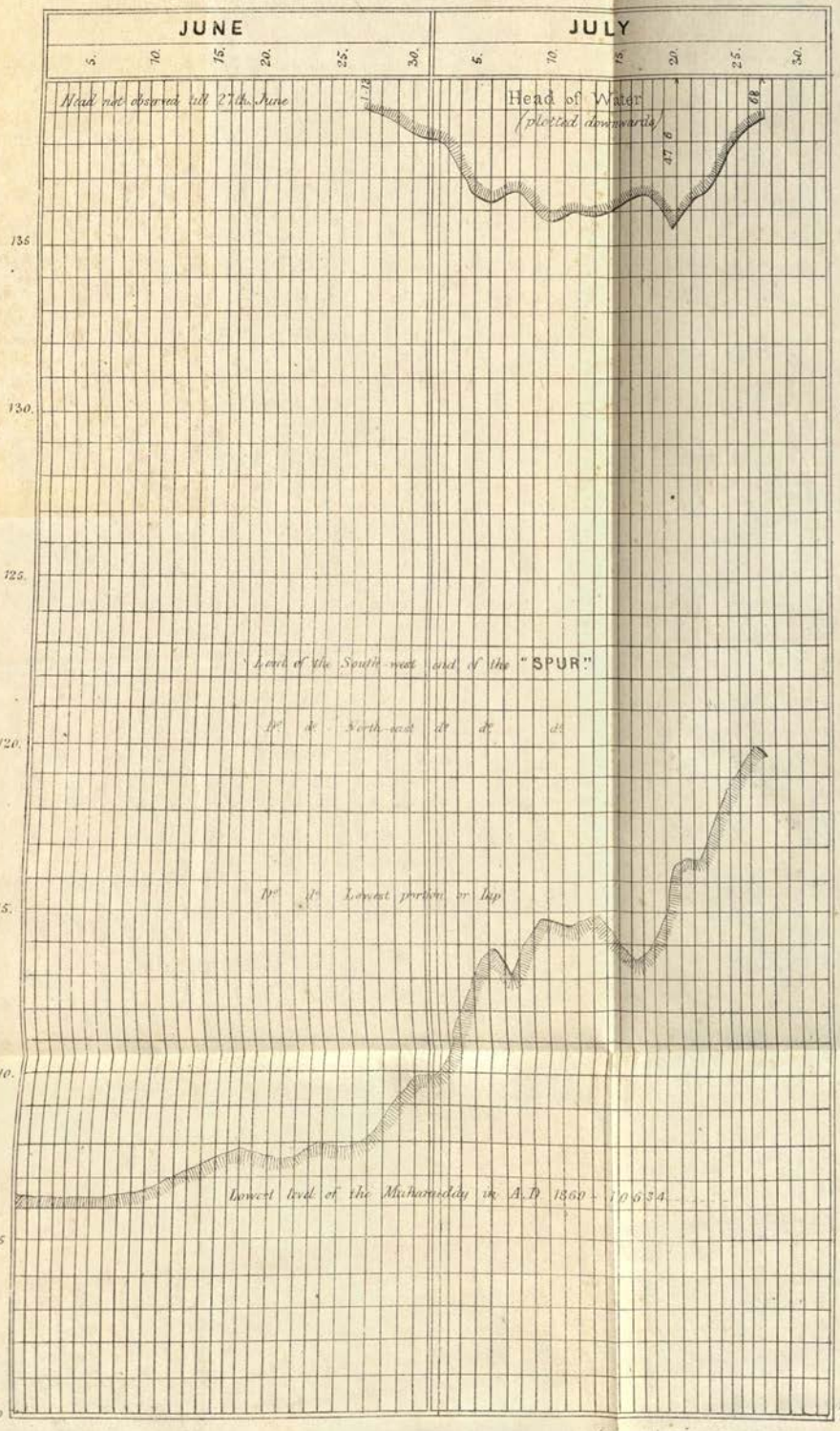
Table of Gauge Observations taken at Naraj and Cuttack, during the first flood of A. D. 1856, *showing the effect of the action of the Naraj Spur.*

1	2	3	4	5	6	7
1860. July. Day.	Simultaneous observations of water level on gauges, (reduced to Cuttack River, Survey Datum.)				Head of water produced by the action of the Naraj Spur.	Remarks.
	A.	B.	C.	D.		
					Feet.	
1	109.86	100.21	99.56	107.94	*1.92	* The "Head of Water" in col. 6, is the difference between the gauge readings of A. and D. (cols. 2 and 5) the gauges at which points are immediately above and below the "Spur."
2	109.86	100.17	99.56	107.93	1.93	
3	110.47	100.33	99.85	108.19	2.28	
4	112.00	100.91	101.10	109.00	3.00	
5	113.24	101.49	101.77	109.45	3.79	
6	113.75	101.87	102.30	109.76	3.99	
7	113.50	101.83	102.20	109.77	3.73	† On the 6th July, 1859, the Naraj gauge stood exactly at this level (119.13) and the readings at B. and C. were *then* 110.22 and 105.17 whereas they are *now* (vide observations of 25th July, 1860) 109.15 and 105.98; from which facts it is deducible that when the Mahanuddy's level is as high as 19 feet on the gauge at Naraj the effect of the Spur is to raise that river at Cuttack, 0.81 feet and reduce the level of the Katjooree there, by 1.07, when the level is lower, greater effect is produced, as may be judged from col. 6.
8	113.08	101.61	101.94	109.58	3.50	
9	114.22	102.02	102.47	110.04	4.18	
10	114.74	102.37	102.92	110.30	4.44	
11	114.60	102.38	102.93	110.26	4.33	
12	114.38	102.23	102.68	110.23	4.15	
13	114.65	102.34	102.74	110.30	4.35	
14	114.70	102.46	103.01	110.38	4.32	
15	114.20	102.24	102.74	110.18	4.02	
16	113.75	101.97	102.43	109.99	3.76	
17	113.45	101.82	102.20	109.84	3.61	
18	113.77	101.90	102.25	109.99	3.78	
19	114.35	102.26	102.75	110.23	4.12	
20	116.17	103.27	103.54	111.41	4.76	
21	116.60	104.76	104.17	112.66	3.94	
22	116.57	104.79	104.22	112.66	3.91	
23	117.70	106.25	104.55	114.58	3.12	
24	118.86	108.46	105.45	116.64	2.22	
25	119.13†	109.15	105.98	117.24	1.89	
26	119.91	110.02	106.42	118.31	1.60	
27	119.77	109.87	106.51	118.09	1.68	

JOHN C. HARRIS, *Captain.*
Superintending Engineer, VII. Circle.

EXTRACT *from the* **NARAJE** Register of daily rises and falls at the HEAD of the **MAHANUDDY DELTA.**

Cuttack 27th July 1860



(Signed) John Harris Captn
Supdt Engr 6th Circle.

WATER-COMMUNICATION

BY THE

MAHANUDDY,

BETWEEN

CUTTACK AND SUMBULPORE.

From the Superintendent Tributary Mehals to the Secretary to the Government of Bengal, Political Department, Fort William.—(No. 4, dated 3rd May, 1858.)

SIR,

IN reply to Mr. Junior Secretary Buckland's letter, No. 1137, dated 23rd ultimo, I have the honor to state that the only impediment to the free navigation of the Mahanuddy, consists in the numerous rocks which are imbedded in the river from Boad upwards, to Sumbulpore and beyond.

2. Whether these rocks could be removed or not without a disproportionate expense being incurred, is a matter on which I have no information, and am hardly qualified to offer an opinion.

3. No doubt their removal, or that of a portion of them, so as to give at least one good safe channel, is a very desirable measure; for at present boats are liable to be dashed to pieces on their downward trip; and on the upward voyage, these rocks are only passed with the greatest labour, owing to the opposing force of the currents and eddies caused by them.

4. The Mahanuddy, in the parts referred to, has never, I believe, been surveyed, and the exact nature of the impediments and the practicability or otherwise of removing them without incurring a disproportionate expense, are unknown.

5. If arrangements for a survey could be made, the measure might be of great service, for whatever tends to increase the traffic between Cuttack, and Sumbulpore, and in fact of all the wild tracts on either side of the Mahanuddy, throughout its entire course, is certain to advance the material interest of the rude inhabitants of the latter and to hasten on their civilization; while the information that would be derived from such a survey, would be of high interest, if of no other advantage.

6. The river is navigable throughout the year as far as Sumbulpore, though the boats used late in the season, are of smaller size than those that are used when the depth of the river is greater.

7. In the rains and for some time after their close, boats come down in great numbers from Sumbulpore and more distant parts, laden with cotton and grain chiefly, taking back cargoes of salt, brass plates, clothes, cocoa-nuts, &c.

8. At such time the average of the downward voyage is about 5 days from Sumbulpore, and 18 to that place.

9. In the hot weather, the water is so shallow in places, that there is often great delay, and the average of the downward voyage may be reckoned at 14 days, the boats used being of small size.

10. The class of boats used, are of peculiar build, being long and narrow, in order the better to thread their way among the rocks obstructing the channels: they carry, however, considerable cargoes.

From C. T. BUCKLAND, ESQUIRE, Junior Secretary to the Government of Bengal, to the Officiating Chief Engineer, L. P.—(No. 1415, dated the 15th May, 1858.)

SIR,

I AM directed by the Lieutenant-Governor to forward to you a copy of the* correspondence as per margin with the Superintendent of Tributary Mehals in Cuttack, regarding the water-communication to Sumbulpore by the Mahanuddy; and to request that you will have the goodness to bear the matter in mind, so that the river may be surveyed whenever efficient agency is available for the purpose at the proper season.

Extract para. 2, of letter to Superintendent T. M. Cuttack, No. 1137, dated 23rd ultimo.
From Ditto, No. 4, dated 3rd instant.

From the Officiating Chief Engineer, Lower Provinces, to the Secretary to the Government of Bengal, Fort William,—(No. 2450, dated 29th July, 1858.)

SIR,

IN adverting to your office letter, No. 1415, dated the 15th May last, I have the honor to submit, for the information of Government, the enclosed copy of the correspondence as per margin, having reference to the water-communication between Sumbulpore and Cuttack, and under the circumstances represented

Letter No. 773, of the 8th July, 1858, from the Superintendent of Embankments, Lower Provinces to the Officiating Chief Engineer, Lower Provinces.
Letter No. 44, of the 17th June, 1858, from the Surveyor of the Cuttack rivers to the Superintendent of Embankments, Lower Provinces.

therein, to recommend that the practical measures proposed by Captain Beadle, for improving the navigation of the Mahanuddy, may be carried out, if possible.

From CAPTAIN J. P. BEADLE, Superintendent of Embankments, Lower Provinces, to the Officiating Chief Engineer, Lower Provinces—(No. 773, Midnapore, dated 8th July, 1858.)

SIR,

I HAVE the honor, with advertence to your letter, No. 730, dated 28th May, 1858, to the address of the Officiating Superintendent of Embankments, to report that having addressed Captain Harris, Surveyor of Cuttack Rivers on the subject of the rock obstructions in the Mahanuddy above its Delta, I have received the accompanying reply, a copy of which is submitted.

2. You will see that I suggested for Captain Harris's consideration, the advisability of obtaining the services of Companies of Madras Sappers and Miners, with their Officers, for the purpose of opening out channels in the rocky beds that obstruct the navigation of the Mahanuddy.

3. If a Company of Madras Miners with an Engineer Officer in command can be made available at the close of the rains, we could take measures for improving the navigation of the Mahanuddy, and perhaps the presence of these Troops in the vicinity of Sumbulpore may not, on other considerations, be deemed inadvisable.

4. I do not wish to detach Mr. Armstrong from his duties during the working season, to go up and inspect the Mahanuddy bed, and it is a work that more properly falls to Captain Harris. Mr. Armstrong's supervising and executive establishments are not strong enough to permit of his being long absent from them.

5. For systematic blasting operation, such as the removal of the rocks will entail, the services of trained men are necessary, and companies of Sappers have, in more than one instance* been made available in the Bengal Presidency for such work.

* Jumna.

From CAPTAIN J. C. HARRIS, Surveyor of Cuttack Rivers, to CAPTAIN J. P. BEADLE, Superintendent of Embankments—(No. 44, Cuttack, dated 17th June, 1858.)

SIR,

I HAVE the honor to acknowledge receipt of your letter, No. 472, dated 11th instant and its accompaniments* on the subject of water-communication between Sumbulpore and Cuttack.

* Herewith returned.

2. You are aware that a very small portion of the river route has been surveyed by me, my levels not having extended further up the Mahanuddy than Byddessur, but the "topographical survey" has, I learn, been carried along one bank of the river the whole distance between the two places named, and a very good map may, in consequence, be obtained from the office of the Assistant Surveyor General at this place. For this I have made application, and that officer's establishment being but lightly worked at present, he has promised to put the map in hand in anticipation of receipt of orders from the Deputy Surveyor General to supply me with it, without which, it appears, that he is unable to comply with my requisition.

3. With the assistance of this map, either Mr. Armstrong or myself could, without much labour, report upon the river during the next cold season.

4. From all I can learn regarding the navigation of the river, it appears to be more obstructed above than below Sumbulpore, and it seems also that the higher up the river the greater the value of the communication; for in the "Chatterghur" district of the Nagpore territory, five maunds of "wheat," "or channah," are procurable oftentimes for a rupee, owing to the impossibility of taking it to a market.

5. There can be no doubt but that the opening out of the Mahanuddy to the extent recommended by Mr. Cockburn will be of the utmost service, and that it will be most satisfactorily executed in the manner suggested by you, i. e. by trained Sappers and Miners.

6. I cannot form any but a very general idea of the extent of obstruction, but it may be characterized, as "very extensive," judging from the subjoined notes extracted from my diary, written after conversation with Mr. Meik, who had made several trips up the Mahanuddy.

" Rocks commence at Dholpore and run into Bodh, distant 14 or 15 " miles ; a head of Bodh is a long stretch of river without rocks to within " 8 or 9 miles of Sonepore, whence they exist to that town, and again " from 25 miles above it to Puddumpore, about 30 miles above Sumbul- " pore (say 50 miles of obstructed channel").

7. Mr. Meik mentions obstructions not being confined to rock, but to "jungle and brushwood growing on them, which interfere with " the passage of boats." He says that "at Hurakoodh," 10 miles above Sumbulpore, the state of the river is the worst.

8. If a company of (Madras) Sappers properly officered, could be spared for the duty of effecting a gradual clearance in the obstructions of the Mahanuddy, the return to Government could not but prove most ample in the end, the officers, without interfering with their duties of supervising the labour of their men, could direct their attention to the discovery of suitable tracts for reservoirs, which must exist without a doubt, and which cannot be "hit upon" readily by the general explorer, basin after basin apparently presenting favorable features might be sketched and levelled by the young Sapper officers, and its actual merits be precisely ascertained; the work being the while a pleasurable relief from the monotony of their ordinary Sapper duties.

9. What casual explorer of the Bankee estate would ever dream that on the removal of its embankments, a reservoir having an area of 95 square miles becomes opened to the flood, and yet this is so. But for Mr. McMillan's being resident on the estate during the flood of 1856, I should not have known to this day "that the flood range was extra-ordinary;" but for his having the leisure to map the flood, I should never have known the "measure of its extraordinary range." I should not in fact have known, but for an expenditure on account of salary to Mr. McMillan amounting to about one thousand rupees, that the embankment of Bankee, positively set on foot only to add that amount to the annual value of the estate, must cause thousands of Rupees' loss annually to the Delta lands of the district.

10. I feel so confident that the judicious employment of labour, whether in blasting rocks in the river or sketching and levelling the peculiarities of feature presented by the country through which it runs, must produce returns for which ample is no name, that I would most earnestly second your views in the matter of obtaining the services of well-trained Sappers to do the work of clearing the Mahanuddy of

obstructions, whereas, knowing the disproportion of return for indifferently directed labour, I could not advocate the execution of the work, under the supervision which the Department of Public Works, as now constituted, is capable of giving to the same.

11. I would reply to your queries "where, when and how," "wherever obstructions exist, let them be removed by (Madras) Sappers "and Miners, whenever their services can be made available."

From C. T. BUCKLAND, ESQ., Junior Secretary to the Government of Bengal, to the Officiating Secretary to the Government of India, P. W. D.—(No. 2536, dated 10th August, 1858.)

SIR,

I AM directed by the Lieutenant-Governor to forward for submission to the Honorable the President in Council, a copy of the correspondence marginally noted, regarding the water-communication by the Mahanuddy between Cuttack and Sumbulpore.

Extract para. 2 of letter to the Superintendent of the Tributary Mehals in Cuttack, No. 1137, of 23rd April last.
Letter from Ditto, No. 4 of 3rd May last.
Ditto to Officiating Chief Engineer, No. 1415, of 15th ditto.
Ditto from ditto No. 2450, of 29th ultimo, and its enclosures.

2. On the 23rd April, the Superintendent of the Tributary Mehals in Cuttack was desired to inquire into the state of the river channel and to report if any thing could be done to improve it. He intimated, in reply on 3rd May, that "the only impediment to the free navigation "of the Mahanuddy consists in the numerous rocks which are imbedded "in the river from Boad upwards, to Sumbulpore and beyond," and that if arrangements for a survey could be made, "the measure might be of "great service."

3. The Officiating Chief Engineer was requested on 15th May to bear the matter in mind, so that the river might be surveyed whenever efficient agency is available for the purpose at the proper season.

4. Captain Young replied to these orders in his letter, No. 2450, dated the 29th ultimo, from which and its enclosures it will be seen that Captain Beadle, the Superintendent of Embankments, states that, if a company of Madras Sappers and Miners with an Engineer Officer in command were made available at the close of the rains, measures could be taken

for improving the navigation of the Mahanuddy; observing at the same time, that "for systematic blasting operations, such as the removal of "the rocks will entail, the services of trained men are necessary; and "companies of Sappers have, in more than one instance,* been made avail-
Jumna. "able in the Bengal Presidency for such work," and this proposal is supported by the Officiating Chief Engineer.

5. The Lieutenant-Governor directs me to state that in his opinion the opening out of the Mahanuddy so as to provide an open channel not only to Sumbulpore, but, if possible to the adjacent districts of Nagpore, is a very important and advisable measure, but as His Honor is not aware whether Madras Sappers are available for the duty proposed, he awaits the instructions of the Hon'ble the President in Council.

From CAPTAIN A. FRASER, Officiating Under-Secretary to the Government of India, Public Works Department, to C. T. BUCKLAND, ESQ., Junior Secretary to the Government of Bengal,—(No. 4523, dated the 17th September, 1858.)

SIR,

WITH reference to your letter, No. 2536, dated 10th ultimo, regarding the improvement of the navigation of the river Mahanuddy, I am directed to inform you that the Honorable the President in Council will defer consideration of the subject until receipt of Captain Harris's report.

No. 3012.

COPY of this letter forwarded for the information of the Officiating Chief Engineer, Lower Provinces, with reference to his letter No. 2450, of the 29th July last, a copy of which and of the previous papers on the subject was sent to the Government of India with my No. 2536 of the 10th ultimo.

By Order of the Lieutenant-Governor of Bengal.

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